COMBINED EDITION

THE Petroleum Engineer

STORAGE ISSUE.....

What's Happening in Liquid and Gas Storage

Underground Storage of Hydrocarbons

Tank Construction for Products Storage

Drilling and Producing | *Refining and Gas Processing* | *Oil and Gas PIPELINING*

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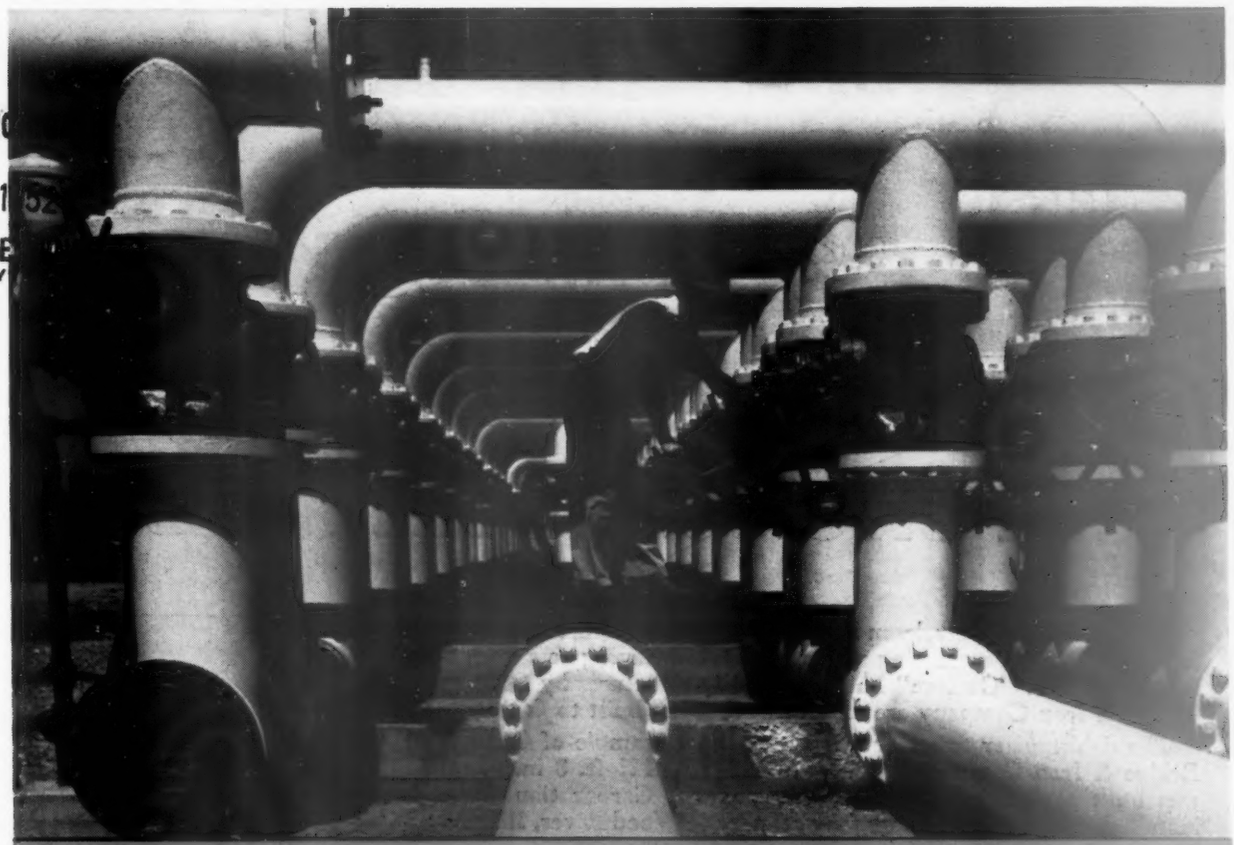

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DECEMBER 1952

Steel Plate Structures for Petroleum Refineries

Throughout the petroleum industry, Horton structures are playing a vital part in increasing production and obtaining new operating efficiencies. "Custom" built steel plate structures by Chicago Bridge & Iron Company are structures that are built to *fit the job.*

The debutanizer tower shown above is an example of Chicago Bridge & Iron Company's "know how." This 121 ft. 8 in. tower was built at Chicago for the Foster Wheeler Corporation to be installed at the Shell Oil Company refinery at Wood River, Illinois. Three railroad flat cars were required to ship it.

The spherical vacuum flasher, illustrated at the right, is another typical example of the "custom" steel plate structures we are equipped to design, fabricate and erect for the petroleum industry. We fabricated this alloy-steel clad spherical vessel to the engineer's specifications and erected it at Shell's Wood River refinery.

Expert design, fabrication and erection of tanks and steel plate structures is offered to the petroleum industry by our experienced engineering staff, plants and field crews. Whenever you need steel structures of any type, write our nearest office for complete information and quotations.

Above: 9-ft. 3-in. inside diam. by 121-ft. 8-in. debutanizer tower. Right: 30-ft. diam. alloy-steel clad spherical vacuum flasher.

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THE Petroleum Engineer

COMBINED EDITION

• Drilling and Producing • Refining and Gas Processing • Oil and Gas Pipelining

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What Is Profit?

AFTER congratulating the petroleum industry at the API Convention on the magnificent job it has done, meeting emergencies again and again after World War II, Secretary of Interior Chapman added:

"Yet I know as you do that eventually — eventually — the present profit incentive alone may prove inadequate to produce the results we must have. Somewhere we are going to have to find something else to help do the job, some adjustment perhaps, some new technique — something."

He profits most who serves best.
Rotary International Motto.

Only a few months ago the demand from Washington was a million barrels a day potential oil production. Now we have that despite steel shortages, price controls, and a strike but we are told that the profit incentive is not enough. "Results we must have" in the future will be inadequately met.

Why? Is this a farewell cry from Administration planners? Or simply a new evidence of the confusion in recent years of what the profit incentive is?

The word "profit" has been torn and tortured. Envious Communist propaganda makes it a symbol of evil lurking in the decadent depths of a capitalist economy. Socialist planners have thrown a murky mantle over the word to fit the conjured despicable doings of shadowy "selfish interests."

What is a man profited if he shall gain the whole world, and lose his own soul.
Matthew.

Others have accepted the innuendoes of the Communist and Socialist and, for that reason, apologize for the great old word. They have absorbed the Marxian idea that profit means a few individuals become rich at the expense of all others.

Actually the meaning of profit is "accession of good," "valuable results," "useful consequences." The historical meaning of the word has been squeezed into a cramped term indicating only $ and ¢ marks. Our capitalistic society is indeed based on the profit incentive but money is one of the means — not the end — of profit.

To the individual, profit means success in his work, freedom to pursue his ideas, respect of his fellow workers, and a good standing in his community. It means the important things of life that come from his business affiliation. A man or woman who has no interest or finds no stimulation in his job is not profiting from it regardless of the money he earns.

No profit grows where is no pleasure ta'en.
Shakespeare.

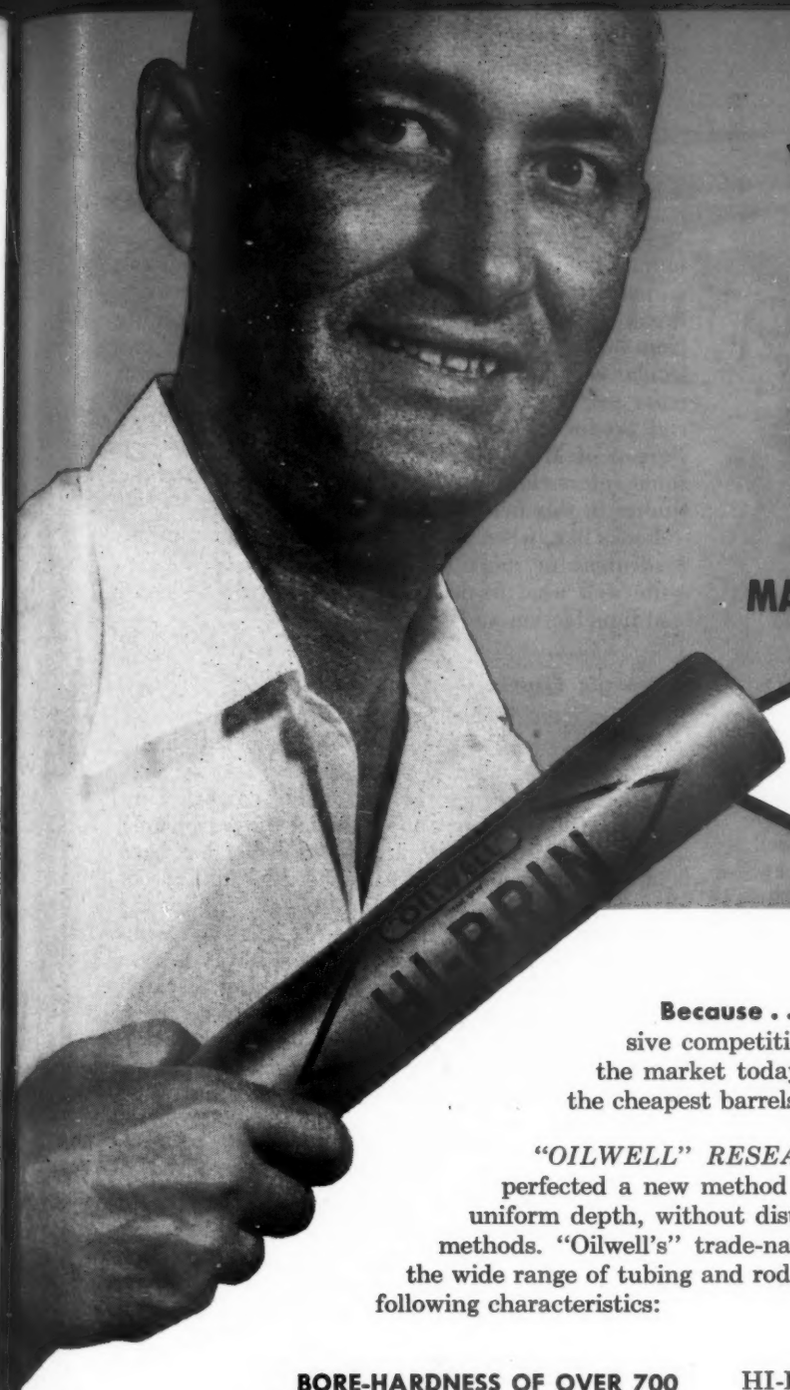
To the oil industry, profit is the ability to satisfy petroleum needs. These demands may be fantastic but somehow they are met and new techniques assembled to converge upon the next difficult task. The essential money profit is fought for to finance visionary drilling depths, distinctive new methods of extracting oil from reluctant fields, amazing new processing ideas, giant distribution systems, and the fabulous expansion of storage, which is reviewed in this issue.

We are now producing 6½ million barrels of oil a day. Can anybody imagine an oil company that would not go all out to double its potential if steel products were available, price and materials controls were off, the tidelands operations were going again, and oil products continue in demand?

In all labour there is profit.
Proverbs.

The profit incentive is the biggest thing in the economic world. It makes it possible for us to "go from strength to strength." It has brought us that which we seek: Accession of good and valuable results.

We don't need some "adjustments" or "some new techniques — something." We just need to take the wraps off the incentive to seek greater profit.—E. A.



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With the EDITORS.....

Significance of Platte Pipe Line

Completion of the Platte Pipe Line Company system, after much travail, is heralded with enthusiasm by oil producers in the Rocky Mountain area. Although production of oil in that region goes back a considerable number of years before the turn of the twentieth century, growth there has been retarded by a lack of transportation facilities. Platte will alleviate this condition to a great extent.

That a pipe line system of Platte's importance should have been beset by so many difficulties, and its completion delayed so many months, is deplorable, even though unavoidable. When the original plans were made early in 1950 there was no Korean War. The supply of steel and other materials seemingly would be available under a peace-time economy; however, with the outbreak of the Korean conflict, shortages became apparent. Instead of receiving pipe and other necessary materials when expected, it was the early part of 1951 before the matter of steel and other priorities was determined by the federal government. Consequently, not until well into April, 1951, did pipe laying get underway. Then the steel strike of 1952 further added to complications and delays. Thus the line, originally scheduled for completion in November, 1951, was not completed until a year later.

It is understandable, then, why the ultimate completion of this project, is considered of such great importance. Initially, Platte will transport approximately 100.000 bbl of crude oil a day. Later this volume will be increased by the addition of more pump stations.

Announcement that the line would be built had an almost immediate effect on the Rocky Mountain oil industry. An increase in geophysical and drilling activity showed clearly the greater confidence that was created by the knowledge of this additional crude oil outlet, and this activity is expected to continue at a relatively high level for the same reason. Furthermore, revenue into the area from the sale of this additional crude oil will provide capital for greater exploration and production, and discovery of new reserves will be the natural result.—F.H.L.

Hydrocarbons From Coal

Hydrogenation of coal continues to hold the industry's eye and new strides are being made, along with carbonization operations to recover liquid hydrocarbons. Pittsburgh Consolidation Coal Company has developed a process for low temperature carbonization of coal to yield solid "coke" and a conglomerate liquid product from which chiefly chemicals and chemical raw materials are to be recovered. Commercialization of this process waits on completion of a $600,000 pilot plant now building and in which technologists will perfect the process for large-scale operations.

Union Carbide and Carbon Chemical Corp. is going the direct hydrogenation route for hydrocarbons and chemicals. In a semicommercial sized plant in West Virginia, where Carbide carries on large commercial operations, the coal molecule is subjected to mild hydrogenation a la catalysis in what their scientists call "chicken-wire chemistry." Purpose is to break up the molecule in rather large lumps, ranging from benzene, naphthalene, etc., to much higher molecular weight products that on the average are worth more per pound commercially, than gasoline, near-end product of hydrogenation, is worth per gallon. Bureau of Mines is progressing carefully and with some interesting results on its rather fundamental studies in this field.

Looks like, when and if petroleum supply becomes inadequate or more expensive, industry will know quite well what to do to augment fuel products by coal liquefaction and just how to do it.—A.L.F.

Geologic Epochs — Or Months?

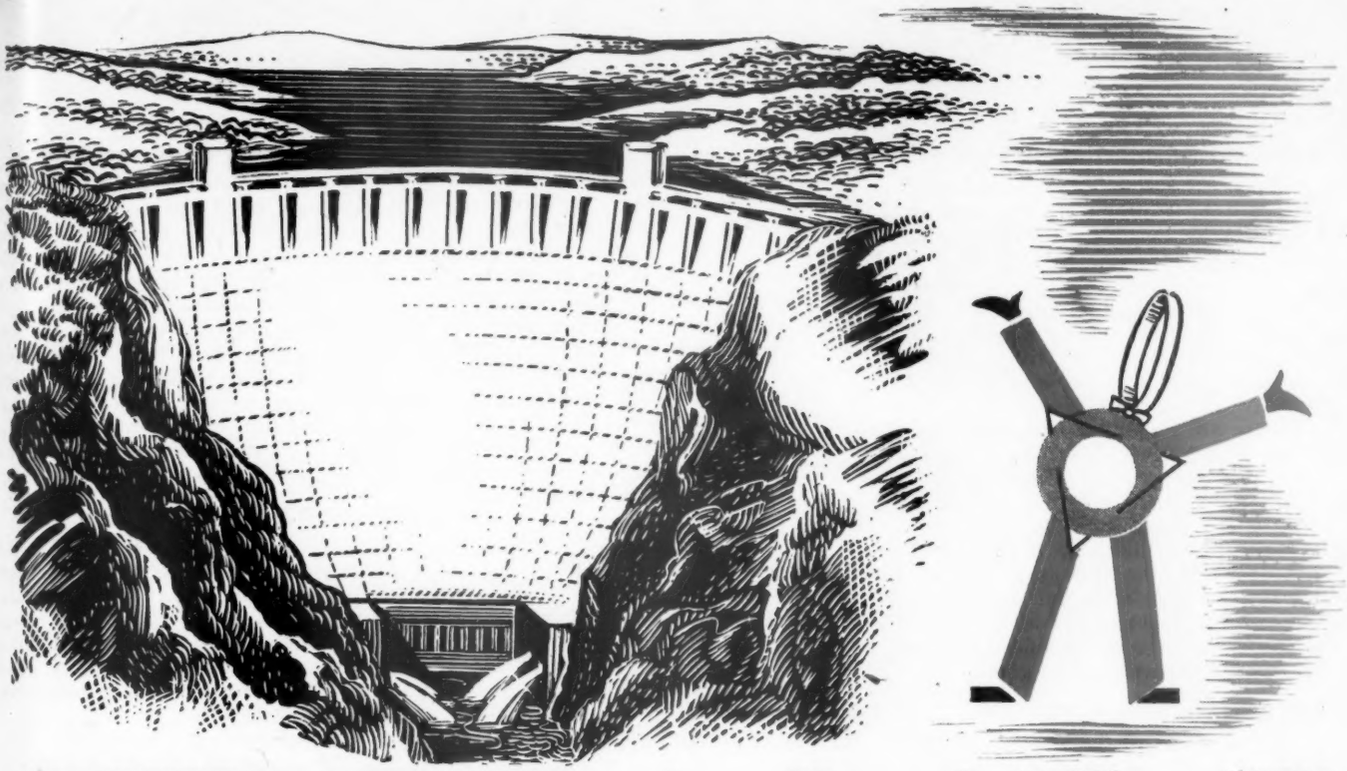
The universally held theory of the formation — synthesis — of petroleum has an excellent chance to be blown sky-high if a new theory, just recently advanced, is proved to be reasonably correct. How long has nature required to synthesize the petroleum?

Since earliest scientific times, the belief has been held and accepted that nature has used millions of years to generate through natural metamorphosis the hydrocarbons that are so important to the present-day economy of the world as we know it. Much data have been collected, long and painstaking research has been carried out to show how oil has been "generated" under terrific heat and pressure within the earth. Carefully developed theories have advanced the notions that petroleum came from vegetable matter, from organic matter, from animal matter, from sea-harbored animalcules, crustaceans, microscopic sea-life, from the metallic carbides within the earth's crust via hydrolysis, and so on.

Now it looks as if all these ideas are to be exploded by new evidences that reduce the formation time for petroleum to an infinitesimal part of eons formerly believed necessary for the synthesis. Dr. J. Laurence Kulp, Columbia geo-chemist has carried out "Carbon 14" analyses of mud from the bottom of the Gulf of Mexico, that is, using Carbon 14 or "heavy carbon" isotope, as an identifying or tracing agent, mud supplied by Paul V. Smith, Jr., of Esso laboratories, and has "proved conclusively" the university says, that oil form in sediment quickly after deposition of the "mud."

These analyses show that the radioactivity of the samples of oil is very high, indicating early genesis. It is known that all organic matter loses radioactivity at predictable rates, rates differing with different kinds of matter but constant within each material category. Calculations based on these facts have shown the age of frozen prehistoric bison meat from Siberia as being 28,000 years in cold storage. Calculations on the oil from the mud samples showed that the oil is "fresh," made within "recent" years. in newly deposited sediments.

While laymen should take the geologist's term "recent" with a grain of imagination, many believe the discoveries of Kulp and Smith will induce oil scientists to take another look at prospecting areas. —A.L.F.



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HIGHLIGHTS IN OILDOM

Oil Future Bright: Nadler

So far as the oil industry is concerned, the outlook is bright, is the opinion expressed by Dr. Marcus Nadler, professor of finance, New York University, at the American Petroleum Institute meeting in Chicago recently. The demand for petroleum and petroleum products will continue to rise, although perhaps at a slower rate. Not only will there be more cars on the roads of the world; not only will more and more diesel engines be used, more farm equipment bought, more homes heated by fuel oil, but also chemical research will accelerate the use of oil as an important raw material. The oil industry, as the rest of industry, will have its ups and downs, but as experience of the past has shown, even a sharp decline in business activity —does not lead to any significant reduction in the consumption of gasoline.

Oil Cartel Charges May Die

Although talk of the alleged international oil cartel has not all died down, it is expected that little if anything else will be done about it. A formal grand jury indictment must be made by January if a case is to be brought against the seven accused oil companies. Even if the indictment is made, however, it is doubtful if the next Congress will give much time to it. District Judge James R. Kirkland has described the oil cartel investigation case before him as a "sensitive case" about a "powder keg" area of the world.

Use of PAD Form Extended

Oil and gas operators may continue to use Form PAD-26LP in applying to the Petroleum Administration for Defense for priorities assistance in obtaining line pipe for the second and third quarters of 1953, Deputy Petroleum Administrator J. Ed Warren announced. Although the form states that approval for its use expires September 30, 1952, Warren said, the expiration date has been extended by the Bureau of the Budget to March 15, 1953.

Under the provisions of NPA Order M-46, the form must be filed by oil and gas operators on or before the first day of the fourth month preceding the calendar quarter in which delivery of materials is required.

API Men Speak

Oil production on the U. S. side of the Williston Basin may reach 100,000 bbl a day within five years, S. F. Bowlby, Shell Oil, told oil men gathered at the API annual convention in Chicago, Illinois, recently. Success ratio of wildcats in the Basin is one in six compared with one in nine in the rest of the U. S., he pointed out.

In another API speech, Ralph E. Davis, consultant, reported that today's natural-gas industry rests on a broad foundation of adequate reserves. Outlining the status of the gas industry, Davis reported that in the last 25 years the annual consumption of natural gas has increased more than five times.

Speaking before a pipe line group at the API meeting, S. M. Blair, vice president, Trans Mountain Oil Pipe Line, stated, "Canada's crude-oil production can reach a rate of 300,000 bbl per day during the summer of 1953, and may be 10 per cent higher by the end of the year." Economical transport from the new Canada fields to the suitable markets is of basic importance to the success and growth of the industry, Blair noted.

Italian-AIOC Suit Moved

The suit against Anglo-Iranian Oil Company in which the Societa Ital-Petrolia of Rome claims it has a right to buy Iranian crude oil, is being transferred from Rome to London, England. The Italian company claims that under Iranian oil nationalization it has the right to buy crude oil and to ship, refine, and resell it on contract with the Italian government. It contends that Anglo-Iranian has prevented exercise of these rights. The agreement to transfer the case came after the British concern presented evidence showing that it did not legally represent AIOC in Rome.

Tidelands Title

The states probably will get complete and undisputed ownership of the submerged lands off their borders as soon as the President-elect takes his oath of office next month. One of the few definite promises made by Eisenhower was his commitment to sign a bill giving the states rights to their tidelands and it is expected to be one of the first things he will do. The election took out of office Senator Joseph C. O'Mahoney, chairman of the Senate Interior Committee, and long time supporter of federal control of tidelands. A look over the list of those elected to both houses of Congress virtually assures titles to the submerged lands will be returned to the states.

First Woman Speaks at API Meet

Oveta Culp Hobby, co-publisher of the *Houston Post*, became the first woman ever to address the annual meeting of the American Petroleum Institute. Speaking at the meeting in Chicago, Illinois, Mrs. Hobby declared that history and evolution are handing to the petroleum industry the greatest of all responsibilities—that of world freedom. The precedent-breaking speaker vowed that "more than a general in the army, more than a battery of defense strategists, more than any one branch of the armed forces—the petroleum industry holds the key to our American safety, to the future of free man." Without oil the armed forces of freedom would be motionless, she added.

Research Centers in Europe

The Battelle Memorial Institute has begun work on a new research center at Frankfurt/Main, in Germany, to serve the industry of that country. Simultaneously with the beginning of this work, another research center, at Geneva, Switzerland, was announced. Batelle has set up a program of fellowships for selected students in the Universities of both Switzerland and Germany. In addition, research centers and fellowship programs for other countries of Western Europe are contemplated for the future.

Free Oil Essential to Supply

Russell B. Brown, general counsel of the Independent Petroleum Association of America, gave "three essentials to adequate oil supplies" in an address in Denver, Colorado, at the annual meeting of the Rocky Mountain Oil and Gas Association. Simply stated, he said these essentials are:

1. The right to free exploration.
2. Market outlet at reasonable prices.
3. A good government atmosphere.

He warned oil men that complete control of the petroleum industry can evolve from government activities that tend to restrict market outlet, control prices, and "otherwise ignore the essentials of a competitive economy."

Commission Lacks Jurisdiction

The Arkansas Oil and Gas Commission does not have exclusive jurisdiction over oil and gas production in that state, the Arkansas Supreme Court has ruled.

The decision of the Supreme Court came out of a suit against Spartan Drilling Company and C. A. Lee by property owners living along U. S. Highway 82, in which they claim salt water permitted to escape from oil and gas wells owned by the two oil interests had caused breeding of mosquitoes to an un-endurable degree. The Arkansas Commission did not figure in the case.

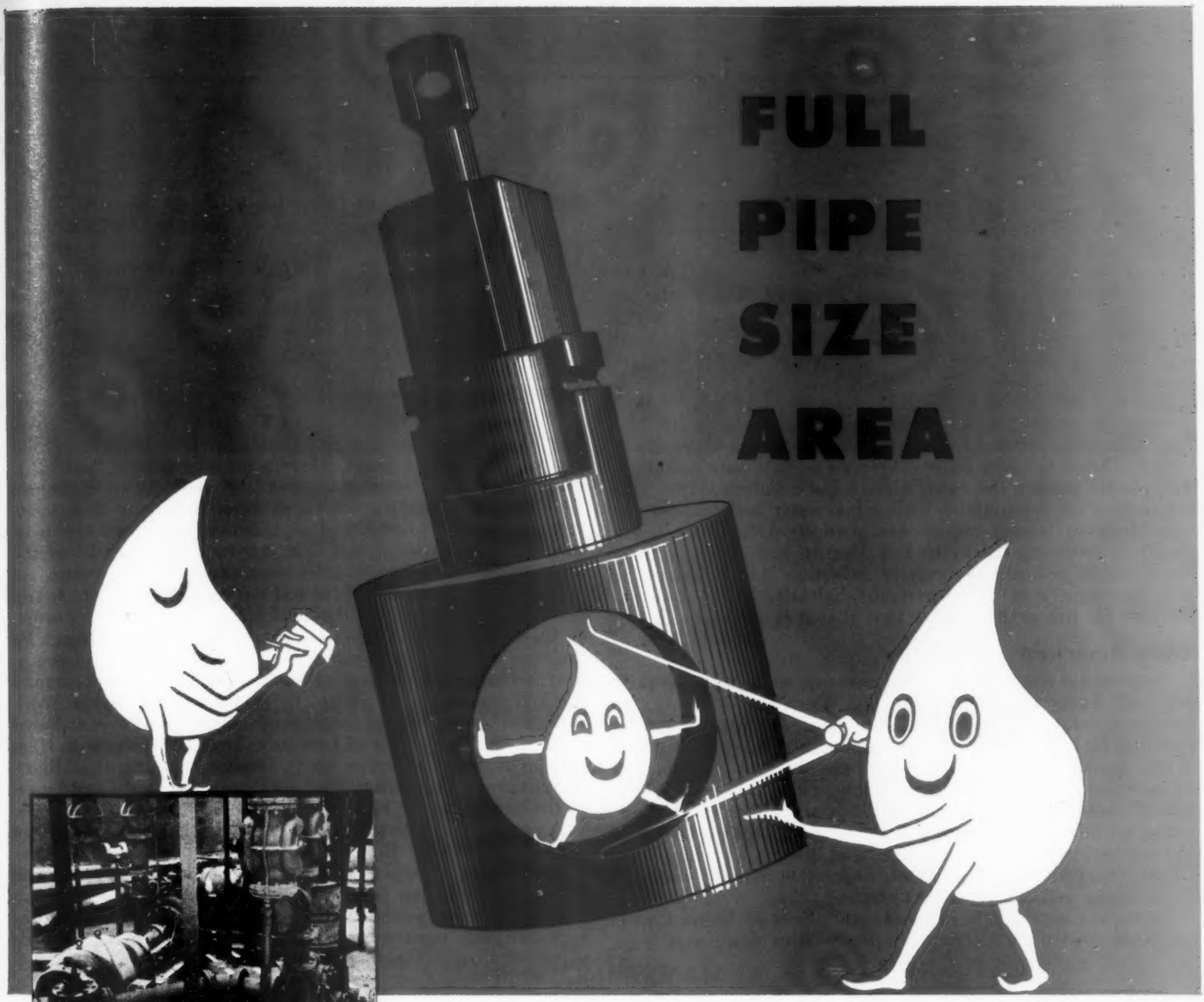
Spartan and Lee had defended their positions by declaring the state Oil and Gas Commission had jurisdiction over the matter. The higher court ruled that the Commission had not adopted any regulations governing the matter and furthermore did not have exclusive jurisdiction.

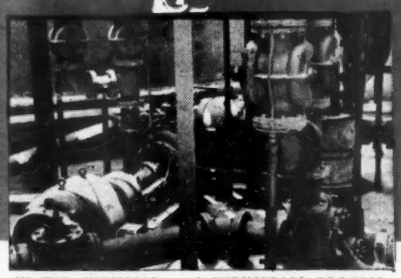
Casing Tubing Allotments Made

Individual allotments of 261,527 tons of casing and tubing to 1804 oil and gas operators for the first quarter of 1953 were made public recently by the Petroleum Administration for Defense.

No allocations were announced for conversion steel, which recently went under stricter curbs, nor were supplemental requests information made available.

PAD had received 2598 applications for first-quarter allotments of tubular goods. Of these 1804 were granted and 794 denied for various reasons.





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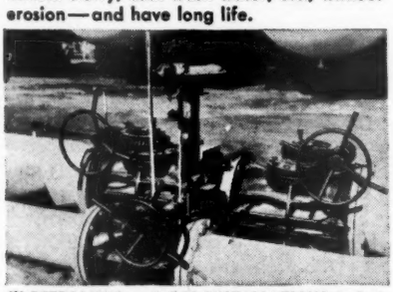

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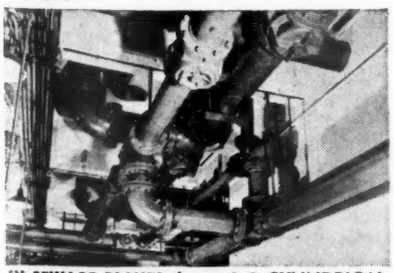

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PETROLIC PERSONALITIES

DICK SNEDDON

B-A Official Down From Canada

Just recently we had a visit from a noted Canadian, Bill Merritt, who officiates as assistant treasurer for the British-American Oil Producing Company up in Toronto, and when we took him to the Los Angeles Petroleum Club for lunch, he was thrilled no end to meet Ham Bell, the drilling contractor. Ham, you see, has been feuding for some time with B-A vice president, O. I. "Tork" Torkelsen over a few centavos exchange, and Bill, of course, was delighted to meet the party of the second part, as it were.

We learned that this Merritt chap, in his younger days, played ice hockey in Winnipeg on the old Wesley College open air rink where the open air frequently got down to 40 below. This is the very place where we ourself once sustained, you should pardon the expression, a gelid auricle. After that we showed up for practice with a hot water bottle under our arm, and our hockey career was abruptly halted. We might mention, returning briefly to Bill Merritt, that he has an unusual hobby — bands, especially Salvation Army bands. He was bandmaster of the Dovercourt Salvation Army band in Toronto for five years, and we hear that it is one of the finest.

Latin-American Hospitality

Imagine our surprise, the other evening, while we were talking with Larry Cannon who is Jack Lewis' assistant in the foreign division office of Drilling and Exploration Company, to find that he is the son of Harley Cannon, the noted consultant. We've known Harley almost since the time of the Spanish Inquisition, but it is still hard to believe that he could have a son of Larry's age. Larry is a USC boy who, after some interesting oil field experience around California, particularly with his dad and another top consultant and domino whiz, Graydon Oliver, shipped to Buenos Aires, Argentina, as field engineer for Drilling and Exploration Company.

He speaks very highly of the kindly offices of Mario Cueto, the Reed Roller Bit Company representative down that way, who made life mighty pleasant for him while he was there. He helped Mario build his swimming pool out in suburban Del Viso and thoroughly enjoyed the experience. Larry's first love in the way of sports is skiing at which he is reputedly a sharpie. Mario Cueto, by the way, is a native of Argentina and a very fine gentleman in all respects. He is a graduate petroleum engineer from the University of Oklahoma, has been with Reed Roller Bit since 1939, and now represents the company in a large part of the South Americas.

Return From Foreign Fields

While in attendance at Los Angeles chapter Nomads' November meeting we had an enjoyable few minutes with several chaps from foreign fields. There was, for example, Cordell H. Vincent, drilling superintendent for Bataafsche Petroleum Maatschappij, and we don't remember in a long time seeing a more careless assembly of alphabetics than there are in the first and last words of that title. Anyway, C. H., as he prefers to be called, is in Los Angeles on a vacation as we write, and being a hopeless addict of the sod lofting pastime, plans to tour the lesser known areas of the local golf courses before returning to his stint at Brunei, Borneo. Hugh Mitchell, the Basrah Petroleum Company toolpusher, is also here for a bit of relaxation and he too flails the good earth amain at every opportunity.

Then there is Ken Smith, the good looking Trans World Management pipe line procurement lad who went over to Beirut in 1947. Ken is a native of Lovelady, Texas, and was with Humble Oil for a while before going foreign. He returns to Beirut in January. We also discovered a pair of newsworthy gentlemen, in the persons of Eli Petersen, assistant drilling superintendent for Shell Oil Company in far away Ventura, and his fellow countryman, Hans Ross, the Baash-Ross biggie. These two chaps were born before the letter j was invented and when the world was suffering from an overproduction of y's. In consequence, they fish yunk out of the hole, employ a yar to get the right drilling impact, and their favorite chorus is a lovely thing, entitled, "Yingle Bells, Yingle Bells!"

Dave Faulkner Retires

A recent series of testimonial dinners honoring David Sinclair Faulkner, retired vice president of National Supply Company, emphasizes once again that, although he would deny the allegation, here is one of the truly great men of the petroleum and supply industry. It is easy to say that of Dave Faulkner because his greatness lies not alone in what he himself has accomplished in a long and distinguished career, but is perhaps more to be attributed to an altogether human concern that has enabled him down the years to encourage and stimulate others to really worthwhile achievement. There are many men in high positions today that can testify and frequently do, to the energizing influence of this Faulkner characteristic. Faulkner was born in the Flickertail state—North Dakota—on November 16, 1885. He later graduated from Purdue in mechanical engineering; did post graduate work at University of Pennsylvania, and began his business career with Otto Engine Works.

Through constant application, keen administrative aptitude, and a genuine love of his fellows, Faulkner has carved himself a prominent niche in the hall of industrial fame. He has made a warm spot in the hearts of countless associates, whom we now join in wishing him many more years of good health and good fortune to enjoy the leisure he has richly earned.

Memorial

Just as the deadline closes in on us we note with deep regret the report that Jack Wilcox, president of Bowen Fishing Tool Company, died on November 18, following a collapse on the fairway of the Lakeside Country Club. Jack, who was one of the best golfers in the petroleum business, was having a game with the Bowen Company attorney, Hamer Jamieson, when the tragedy occurred. Jack Wilcox was widely known in the petroleum industry and many friends will mourn his passing.

Modern pressure tanks for butane and propane, cone roof tanks, and floating roof tanks at cycling plant.

P 600.

Evolution of the Oil Tank

Early wooden barrels have given way to wondrous designs of flashing silver with capacities reaching 120,000 bbl

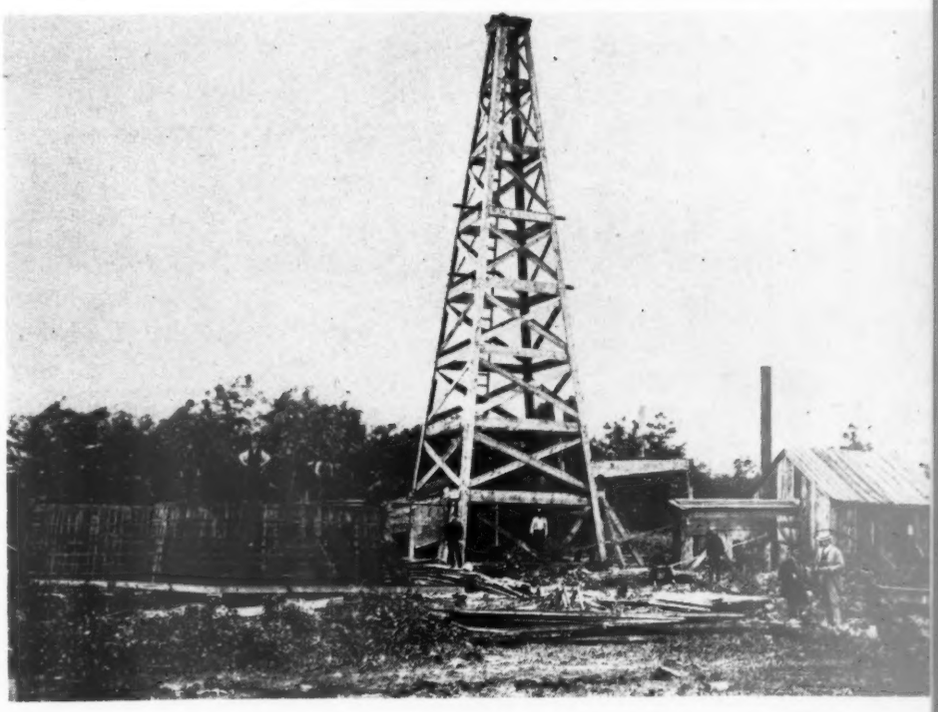
E. N. ZIMMERMAN

BIRTH of the petroleum industry dates back to August 27, 1859, when William A. (Uncle Billy) Smith and his two sons drilled Colonel Drake's discovery well on the banks of Oil Creek, near Titusville, Pennsylvania. Since that time oil men have been faced with the problem of how to handle the oil they took out of the ground. In the early days the answer was simple—ordinary wooden barrels were plentiful enough to hold the crude oil produced, and if barrels were not available, shallow pits were dug in the earth to serve as makeshift reservoirs.

No one worried much about losses from leaks and spillage because every day saw new wells bringing more and more oil to the surface, nor did the question of evaporation receive much attention because the production of the early refineries was limited to kerosine and crude lubricating oils. Fire, of course, was a menace. It was regarded as a necessary evil, about which little could be done, except to exercise ordinary care.

One or more ancient cannons, usually of Civil War vintage, for many years were an essential part of tank farm equipment. They were used in making

The Lady Stewart well at Shamburg, Pennsylvania, in 1875. The wooden storage tanks at left are nothing more than overgrown barrels. The first tank cars were a couple of these wooden tanks set on a flat car.

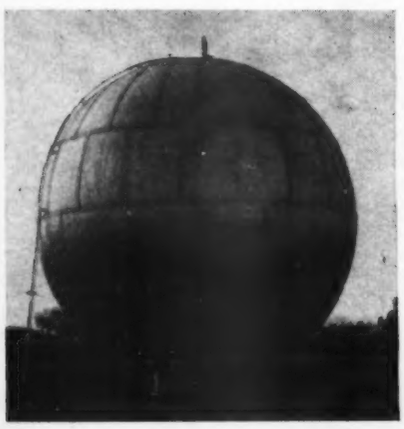


EXCLUSIVE

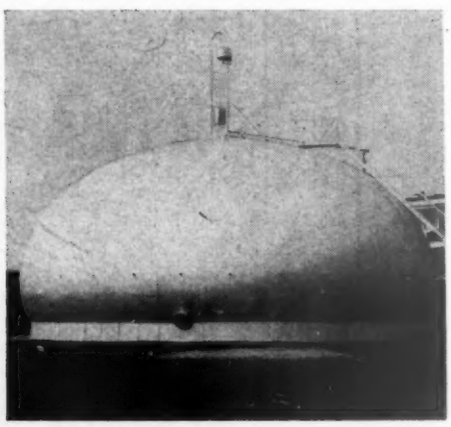
Among the first floating roof was this one built at Cushing, Oklahoma, in 1922. They were built with pan type decks.

The first Hortonspheres, shown above, were built in 1923, were used for liquid storage at Port Arthur, Texas.

Welding bottom of an oil storage tank in Oklahoma in 1923.



This Hortonsphere, which is 57½-ft in diameter, was installed at Phoenix, Arizona, in 1925 to store gas under pressure.



The Chicago Bridge and Iron Company built this experimental smooth Hortonspheroid at its Chicago plant in 1928. Structure has a capacity of 10,000-bbl and is designed for 5 psi pressure.

holes in the tank of oil when it caught fire, letting the oil flow into the surrounding dyke before it boiled over from the heat or exploded and caused more serious damage to the immediate area.

Wooden barrels and earthen reservoirs could not cope with the rising flood of oil that poured out of the Pennsylvania wells. According to an entry in the *Oil City Derricks Handbook* in October 1861, "So much oil is being produced that it is impossible to care for it and thousands of barrels are running into the creek. The surface of the river is covered for miles below Franklin. Some wells are being plugged to save the production. Fears are entertained that the supply soon will be exhausted if something is not done to prevent the waste."

Frantically the industry turned to building the first storage tanks, which were nothing more than overgrown barrels standing upright on the ground. Some of the barrels were equipped with roofs and others were left open. Oil poured out of the ground in increasing quantities and still larger tanks were needed. In September 1864, the *Derrick* ported: "Graff Hasson and Company have erected one large iron tank of an estimated capacity of 8000 bbl and intend to erect two more of the same size at Oil City, Pennsylvania. These tanks are intended to hold crude petroleum and will be covered with gravel roofs and secured from fire or leakage."

With the production of steel started shortly after the Civil War, the petroleum industry turned to steel tanks of bolted and riveted construction and the maximum size was increased to about 35,000 bbl. The period from 1915 to 1920 saw an increase in the capacity of steel tanks. Many 55,000-bbl tanks were built and in 1919 the first 80,000-bbl tank was constructed. Over the years the capacity of tanks has been on the increase and today steel tanks are available in many standard API sizes from 500 bbl to 268,000 bbl, ranging in size from 15-ft diameter to 200-ft diameter.

In the early days when electric welding was first used to join steel plates to-

gether the process was performed with bare electrodes. It was almost impossible to control the weld and the variance in the strength of joints made it undesirable for welding joints which were required to take stress.

In the early 1920's, more and more welding was being done and it became standard practice to weld tank roofs and bottoms as they are not required to take calculated stress. With the introduction of the electric shielded arc process in the early 1930's it gave better control of the weld and it then became possible to weld entire tanks.

At first the welding of complete structures was limited by the availability of current or portable generating equipment and, to some extent, by weather conditions. The constant improvement in electrodes, technique and equipment have made it practical to use welded construction at almost any location.

Years ago one style of tank was used to store all products of petroleum. Today many products require specially built containers. In the modern refinery there are spherical vessels, spheroidal vessels, cylindrical tanks, flat-bottom tanks with floating roofs, and vapor-saving roofs. Heavy iron plates have been replaced by thinner, lighter and stronger plates of steel. Bolts have been replaced by rivets and the latter in most installations has given way to welding. The gravel roofs which covered the tanks in the early '60's have been replaced with floating roofs which rise and fall with the liquid as they protect, or roofs that provide a temporary storage place for the vapors from the tanks in which the liquid is installed.

Practically every major improvement in storage vessels has been aimed primarily at eliminating evaporation and improving fire protection.

Today there are three general classifications of containers intended to prevent or reduce evaporation loss—(A) liquid volume change tanks, (B) vapor volume change tanks, (C) pressure change tanks.

The outstanding feature of group "A" containers is their ability to adjust themselves to varying liquid volumes, always keeping their retaining surfaces in contact with the liquid. Tanks equipped with floating roofs fall in this group. There are in general use today three types of floating roofs—(1) double-deck floating roof, (2) pontoon floating roof, (3) pan floating roof. The double-deck roof has a double deck over the entire liquid surface. The pontoon floating roof has an angular pontoon around the outer edge of the roof and a deck of single thickness at the center. The pan floating roof has a deck of single thickness and vertical rim at the outer edge. The first successful floating roofs were built at Cushing, Oklahoma, in 1922. They were built with pan-type decks until the pontoon type was developed in 1928. The first double-deck floating roofs were built in 1946.

The predominant feature of group "B" containers is their ability to adjust themselves to varying vapor volume, either at constant or variable pressures. Tanks with vapor-saving roofs fall into this classification.

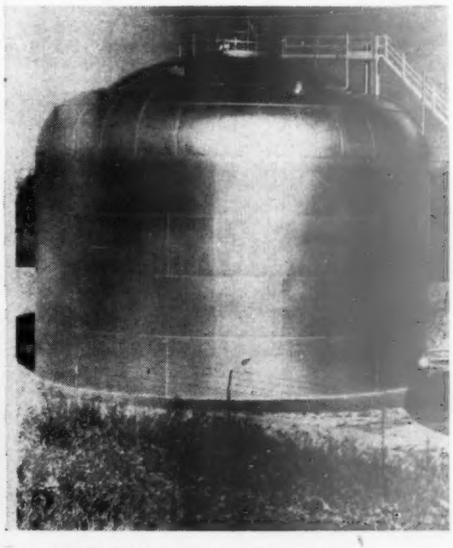
A distinguishing feature of group "C" tanks is their ability to keep the combined liquid and vapor volume con-

These 30-ft diameter by 15-ft high pontoon floating roofs were built at Wood River, Illinois, in 1930.

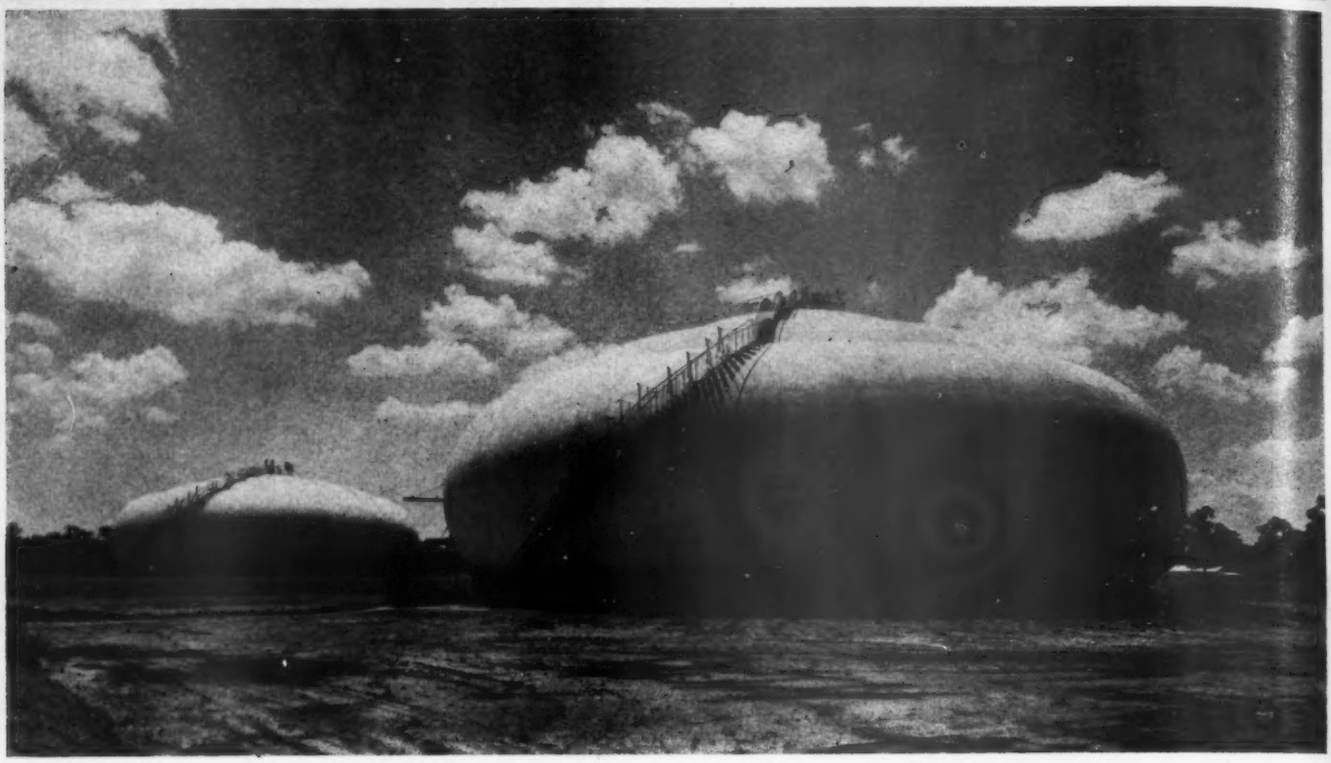
The Author

E. N. Zimmerman is a special engineer in the technical information department for Chicago Bridge and Iron Company. He joined the company in 1937 in the Greenville, Pennsylvania plant in the drafting room, and in 1942 was transferred to the purchasing department as a special engineer in coordinating and purchasing material for drydocks and LSTs, which the company was building. In 1945 he was transferred to his position in the general sales office in Chicago. He is former editor of the Greenville Record Argus, daily newspaper.

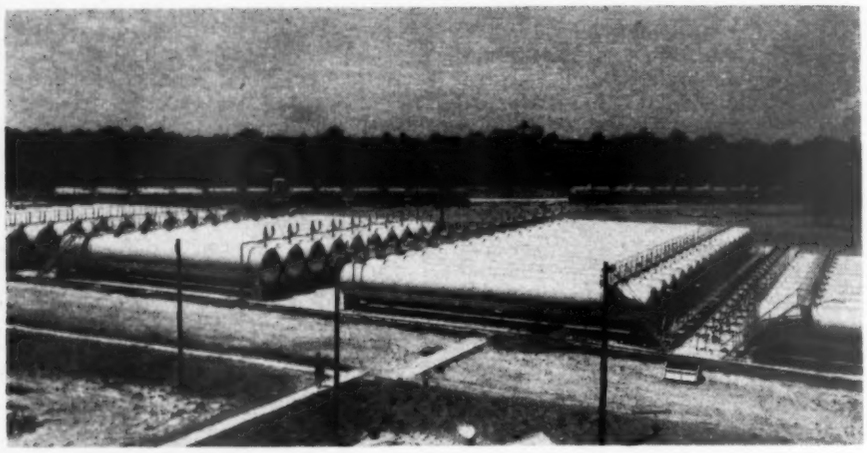
This first Hortonspheroid, built in 1929, was of riveted construction. It was the smooth type of design and has a capacity of 2000 bbl.



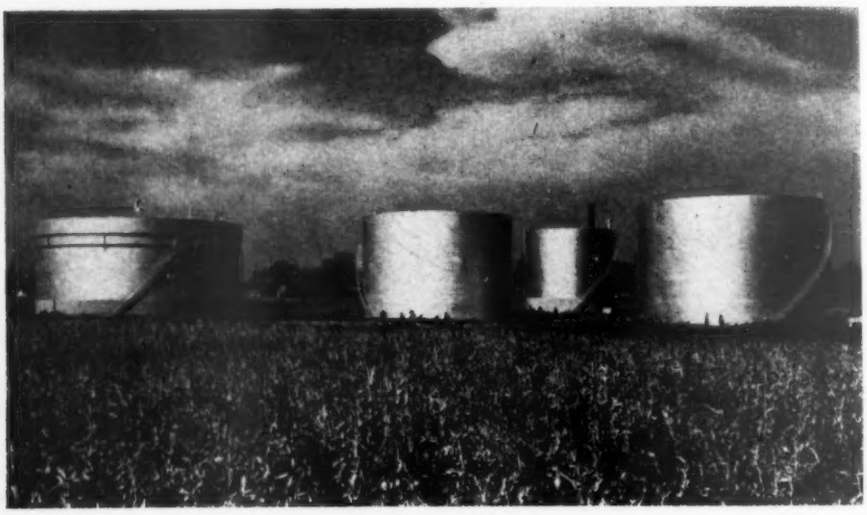
A 20,000-bbl Hemispheroid built at Hartford, Connecticut, in 1939. It has a straight-sided shell, noded roof, and is designed for 2½ psi pressure.



This 100,000-bbl Hortonspheroid used to store natural gasoline is the noded type and designed for 45 psi pressure.



Cylindrical tanks for propane are 106 in. in diameter and 67 ft ½ in. long.

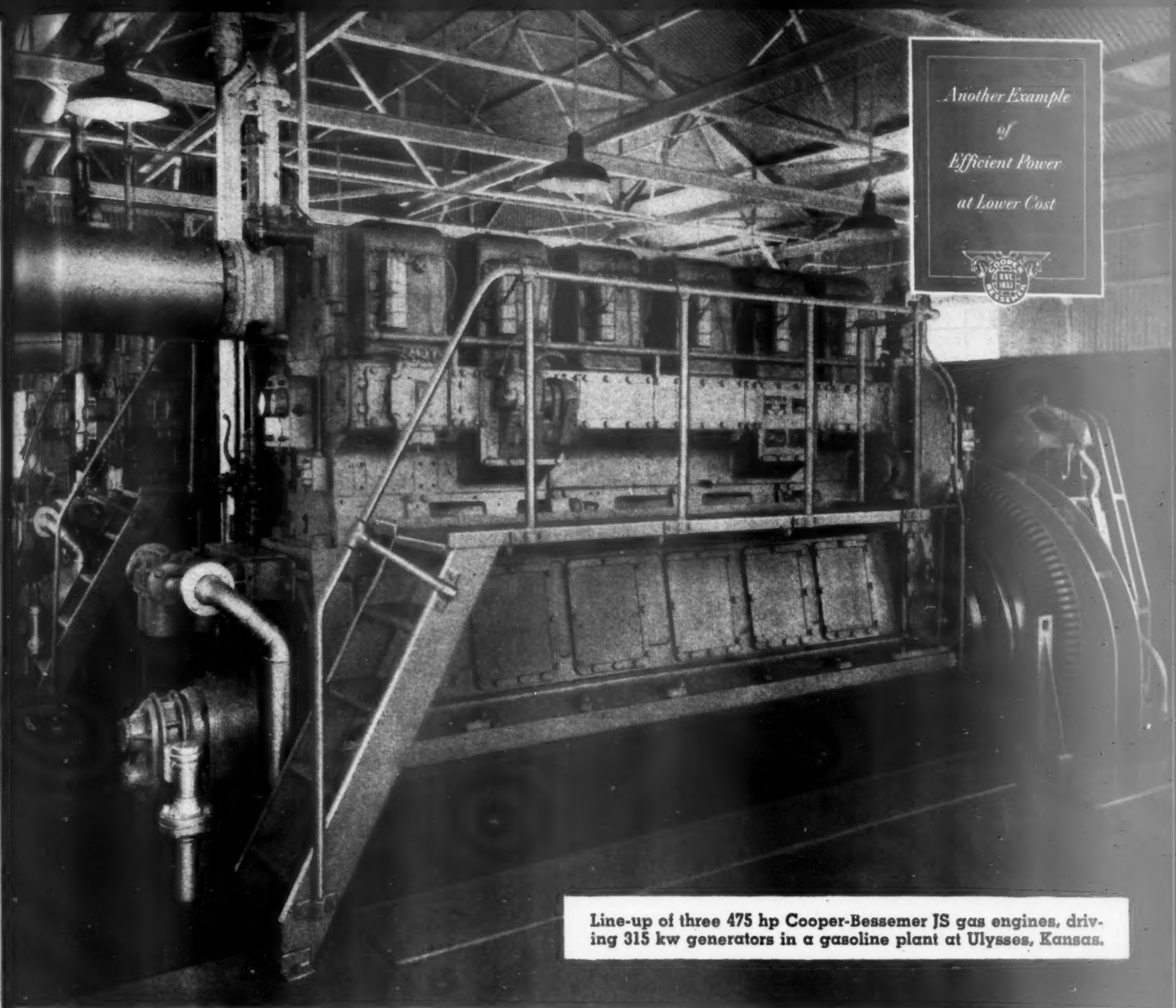


This view shows a 55,000-bbl tank with a lifter roof connected to the vapor space of several cone roof tanks.

stant by withstanding internal pressures developed under storage conditions. Conventional storage tanks with vertical cylindrical shells, flat bottoms, cone, or dome roofs with conservation vents fall in this group, but are so weak structurally that they are effective up to a very small pressure—not more than an ounce or two per square inch for large tanks with low-pitched cone roofs. Spheroidal, spherical, and cylindrical pressure vessels fall in this classification and are effective over large pressure ranges and may be effective for high internal vacuums. The first Hortonspheres were of riveted construction and were built in 1923 for the storage of liquids at Port Arthur, Texas. Two years later a 57½-ft diameter Hortonsphere installation was made at Phoenix, Arizona, to store gas under pressure. Since that time Hortonspheres have become a common sight in the petroleum industry and today are built as large as 30,000 bbl capacity and 69 ft in diameter for the storage of liquid and 80 ft in diameter for the storage of gas.

In 1928 a 10,000-bbl Hortonspheroid, designed for 5 psi pressure, was erected at the plant of the Chicago Bridge and Iron Company in Chicago for experimental purposes. The first actual Hortonspheroid installation was made in 1929 and was known as the smooth spheroid and had no internal framework. The success of the smooth spheroid led to a demand for larger pressure vessels. Gradually the design of the smooth spheroid was modified and the noded spheroid, which contains internal framing, was developed. Today the petroleum industry is using Hortonspheroids with capacities from 2500 to 120,000 bbl.

Vapor-saving systems and vapor-saving roofs reduce evaporation loss from



Line-up of three 475 hp Cooper-Bessemer JS gas engines, driving 315 kw generators in a gasoline plant at Ulysses, Kansas.

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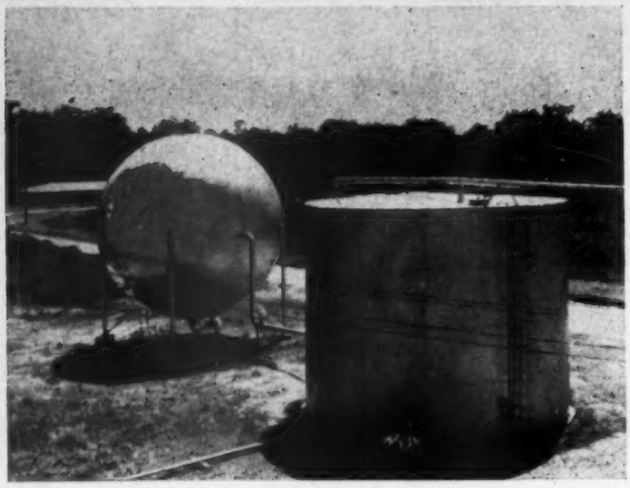
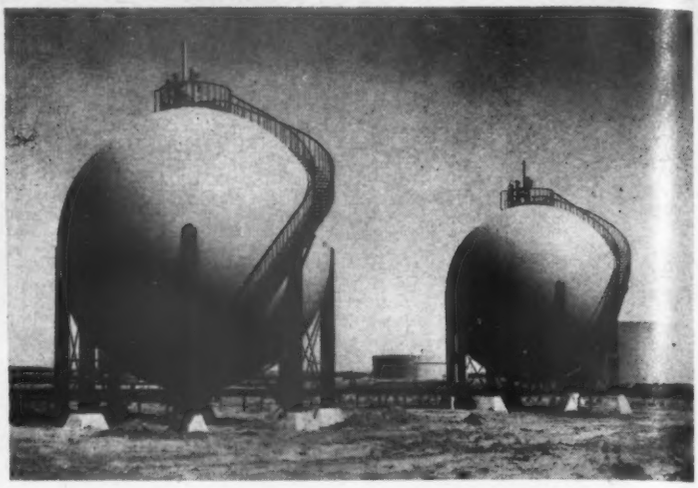
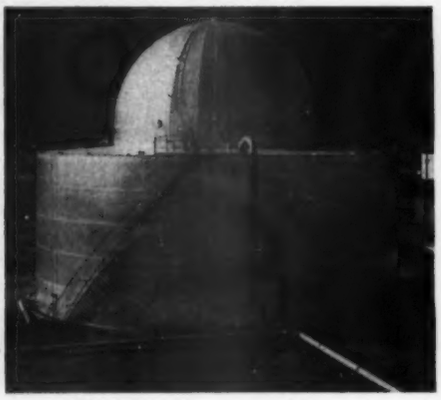


Vapor spaces of one 109,000-gal and one 382,000 gal flat bottom tanks are connected to this 10,000 cu ft Vaporsphere. The vapor line is shown passing over the cone roof tank.

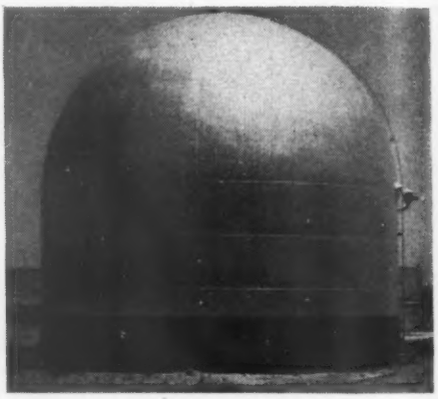


These Hortonspheres provide storage for butane. They are 38 ft in diameter and designed for 85 psi pressure.



A 55,000-bbl tank with 100,000 cu ft Hortondome roof. Vapor line in foreground is to an 80,000-bbl cone roof tank storing premium gasoline.

The above 20,000-bbl gasoline tank is equipped with a double-deck floating roof.



This Vaportank has a capacity of 50,000 cu ft and is used for temporary storage of vapor displaced from connected cone roof tanks.

Mounted Barrels Were First Tank Cars

Less than two years after the Drake well was brought in, transportation became the number one problem. At first 16- and 18-horse hitches attempted to pull wagons loaded with oil barrels from the wells to the marketing terminals. Later this was replaced by barges and rafts, commonly called "oil boats."

In 1865 the car tank, mounted on a railroad flat car, made its appearance. These tanks were similar to the small iron hooped wooden tanks at use at the wells. They were round and the diameter at the top was smaller than the diameter at the bottom and they would hold 40 to 50 bbl of oil.

In the late 1860's, the forerunner of the present type of tank car was introduced. It was a design of car in which a horizontal cylindrical tank with 80 to 90 bbl capacity, replaced the two small wooden tanks. A radical change was made in the design—the tanks were fitted with a dome which allowed the oil to expand without injury to the tank. This was later increased to 100 bbl which became the standard for that period. The high cost of transportation necessitated the development of a more economical means of transportation. The first successful pipe line for transporting oil was constructed by Samuel Van Syckel. It was a 2-in. line, 5 miles in length extending from the well to the Miller farm. There was little or no leakage and 800 bbl of oil could be pumped through the line in the period of a day.

The first oil trunk pipe line, built of 4-in. pipe, 60 miles long and capable of carrying 7500 bbl of oil daily, running from the Pennsylvania oilfields to Pittsburgh, was completed in 1874 by J. J. Vandergrift and George W. Foreman. A pipe line crossing the Allegheny Mountains to the Atlantic seaboard was started in 1878.

In 1861, the first transoceanic shipment of oil, 5 bbl, went from Philadelphia to London. The first ocean-going vessel equipped with iron tanks for petroleum transport was the "Charles" which sailed between the United States and Europe. It had 59 separate tanks with a total capacity of 714 tons and carried a cargo of crude oil. Each year additional vessels were adapted to carry oil in bulk and by 1885 more than 1000 vessels, mostly foreign, were transporting from 2500 to 14,000 bbl of American oil per voyage.

standing storage tanks. They provide a variable volume vapor space, which allows the air vapor mixture from the liquid in a tank to expand and contract without venting vapor to the atmosphere. Included in this group are tanks that are equipped with lifter roofs, which move upward to provide space for additional vapor volume and downward when the vapor mixture contracts. Also, in this group are structures of spherical and cylindrical shapes with a flexible membrane on the inside attached to the steel shell. When thermal expansion occurs or a tank is filled, the flexible membrane moves upward to make room for the increased vapor volume or the vapor that is displaced by liquid. When there is a contraction of air vapor mixture due to decreasing temperature, or when liquid is withdrawn from the tank, the flexible membrane moves downward. Some of these structures are designed so as to contain liquid in the tank proper and others are designed only to act as independent units to reduce evaporation loss by storing the vapors from other connected cone roof tanks. The tanks which contain liquid can also be interconnected with other cone roof tanks to prevent loss of vapor. * * *

Underground Oil Storage

Edholm container, developed in Sweden, uses excavations or caverns and ground water to store large quantities of fuel oil

DOUGLAS BALL*

In recent months underground storage of liquid hydrocarbons has been much in the news. At a time when steel is hard to get and product demand high, any reasonable storage bet looks good and underground storage offers interesting possibilities and advantages over conventional types. The seasonal variation in demand, the price of the LPG products, and the high costs, around $20 per barrel, of LPG storage in steel tanks gave the initial impetus to underground storage in the United States, and at present over 2,000,000 bbl of United States underground storage is for LPG. In Europe, however, a move to underground hydrocarbon storage has been sparked primarily by such storage's tactical security and ease of camouflage. High priced underground steel tankage is in use in several countries. Security—not economics—justified it, but lack of knowledge of less expensive methods has forced its use.

For some time engineers on both continents have looked longingly for an economical way to seal underground mined or natural caverns, for such caverns could go a long way toward providing a company's or a country's storage needs if they could be made leakproof. Rocks without appreciable porosity and fractures are not common; furthermore, most rocks "competent" to maintain open caverns are brittle enough to fracture readily. In rocks other than salt, sealing a natural or excavated cavern to make it oil tight presents serious problems of technique and cost.

The Container

In the early post-war years in Sweden, Harald Edholm, Purchasing Director of the State Power Board, faced with the problem of storing the large quantities of fuel oil needed for Swedish steam plants, developed what is known as the Edholm container,[1] an underground excavated or natural cavern for petroleum storage with any permeable part of its walls or roof below the water table, which relies on the presence and pressure of the surrounding ground water to prevent loss of the stored material. It can be designed to store any petroleum hydrocarbon. An Edholm container may or may not break the surface; it can be as deeply buried as desired for protection from fire, explosion, or bombing hazards.

Edholm containers may be abandoned mines or quarries or may be constructed for the purpose. They are so designed or placed and so operated that the surrounding ground water pressure is greater than the pressure of the stored material at the same depth and time. Pores and fissures in the rock walls or roof need not be sealed other than with the ground water. Because the pressure of the ground water is greater than the pressure of the stored material, leakage through such pores or fissures is ground water entering the tank, not stored material leaving it.

Suitable Rocks

Suitable rocks for Edholm containers range from hard or "competent" rocks to unconsolidated sands and gravels. The rock must be chemically inert to water and to the stored hydrocarbon and must not be readily soluble in either. The chief construction problem is that of mining the rock. Caverns in competent rocks can be designed and mined so that walls and roof are self-supporting; caverns in less competent rocks must be adequately shored to maintain the desired dimensions; large-diameter caissons may be sunk and roofed in sands or gravels.

Crystalline rocks such as granite, basalt, gneiss, and schist are usually competent. They are generally very dense and at least partly fused; their primary porosity is small and the pores are not well connected. They are usually brittle and highly fractured. Ancient water tables enduring over long periods of time have pretty well removed such soluble substances as they may have contained in the places where they are likely to be mined for storage tanks.

Most limestones are competent; some are relatively impermeable, many are permeable due to crystallization, dolomitization, jointing, and combinations thereof. Sandstones are mainly competent, permeable, and water-bearing, although many of them are well enough cemented to make them relatively impermeable.

Shales and coal are generally incompetent rocks. Shales tend to flow under stress; coal is usually brittle and liable to fracturing. Both usually contain at least traces of organic materials soluble in most petroleum hydrocarbons and both usually lose structural strength when wet with water. Certain of them, however, may be usable for Edholm containers under limited conditions.

Most sands, gravels, silts, and muds are structurally too weak to constitute stable walls for a cavern, but caissons may be sunk through them, with the unbottomed caisson serving as a container.

Function and Requirements of Ground Water

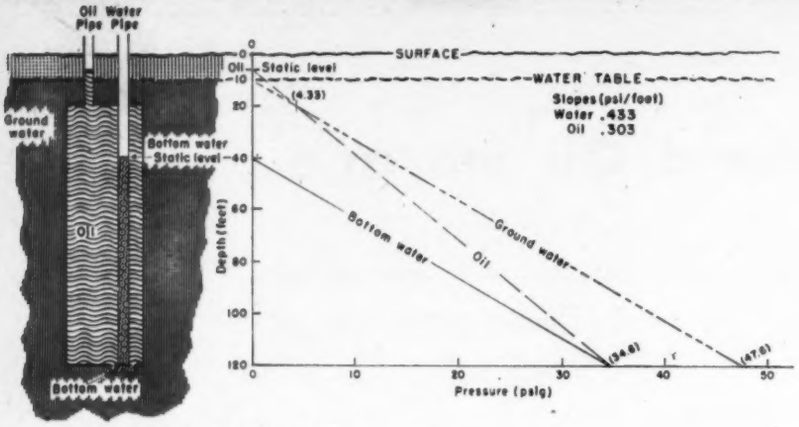
Ground water is all important in the use of the Edholm container. By keeping the top of the stored product, or the highest level at which the container wall is permeable, enough below the top of the water so that the water's pressure at any greater depth is higher than that of the product at the same depth, the

The Author

Douglas Ball joined his father, Max Ball, in his oil and gas consulting practice in Washington, D. C., in 1949. For three years previous to that he had been employed with Phillips Petroleum Company as a gas engineer in the Panhandle and Hugoton gas fields. He was graduated from Colorado School of Mines in 1943, and after which he joined the Army Corps of Engineers. He spent 20 months in India with the 789th Engineer Petroleum Distribution Company as a petroleum engineer and safety officer during the laying of the Army's Bengal-Assam pipe line, largest products line in the world. During the company's 20-month stay in India, Ball was commanding officer in charge of maintenance and operation of the Parbatipur-Jogighopa section of the line, and for a part of the operation, of the Brahmaputra crossing and pipe line to Gauhatti. He was released from active duty in 1946, at which time he joined Phillips.

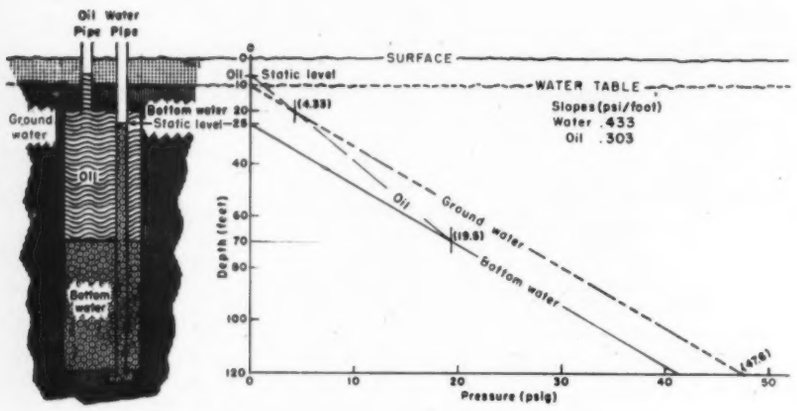
[1]Data on the Edholm container in this article are from: "The Edholm Container for Oil Storage," a report prepared for Henrik Mannerfrid, Inc., 52 Wall Street, New York, by Max W. Ball and Douglas Ball, May 1952.

EXCLUSIVE



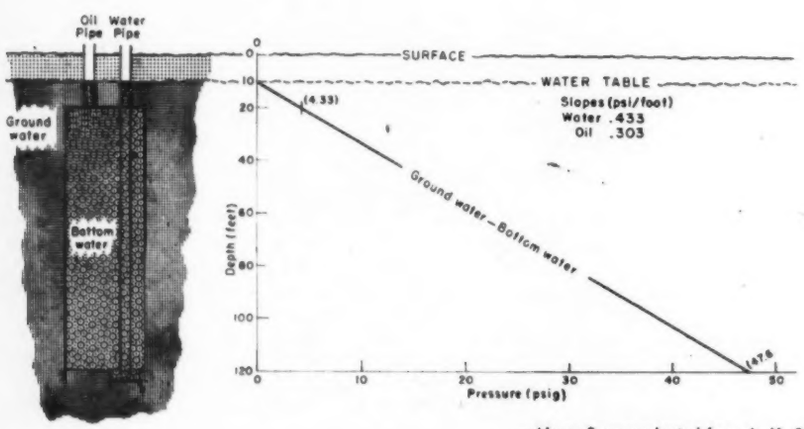
Oil static level, 6 ft below surface
Water table, 10 ft below surface
Bottom water static level, 40 ft below surface
Oil-water interface, 120 ft below surface, bottom water and oil pressure, 34.6 psig
Tank top, 20 ft below surface, oil pressure, 4.33 psig
Tank bottom, 120 ft below surface
Specific gravity of oil, .700

FIG. 1. Diagrammatic sketch of full Edholm container.



Oil static level, 6 ft below surface
Bottom water static level, 25 ft below surface
Oil-water interface, 70 ft below surface, pressure 19.5 psig
Specific gravity oil, .700

FIG. 2. Diagrammatic sketch of half full container.



—Above figures adapted from A. V. Rossi.

Bottom water curve concides with ground water curve

FIG. 3. Diagrammatic sketch of empty Edholm container.

water forms the seal that keeps the product in the container.

For a product less dense than 10 deg API, the required pressure differential between oil and water can be maintained with the water level only slightly above the exposed oil level, and the water may provide the lift to bring the product up in the container when the container is being emptied of product.

The key to the method is the maintenance of a condition of non-equilibrium between the water and the product by continuous or intermittent removal of water. If no water were pumped out, the pressures within and without the container would equalize, and the water would no longer be an effective seal. Pumping water out of the bottom of the container at the proper rate (or out of the top if the product gravity is lower than 10 API) keeps the pressure within the container below the water pressure outside, and the higher outside pressure keeps the product within the container.

The rate at which ground water enters the container is regulated by the difference in the pressures within and without the container. The oil and bottom water in the container exert a back-pressure against the water in the walls and floor and thus decrease the rate of water inflow. In the two Edholm containers now in use in Sweden the inflow of water is only about 10 bbl a day, although the wall rock is highly brecciated.

In most places the water table is not flat over a large area; it undulates, conforming roughly but not exactly with the ground surface. Moreover, the water table is likely to vary seasonally. The undulations and seasonal variations are known and have been mapped in most areas.

As ground water that seeps into the containers must be pumped out in order to keep pressure in the tank lower than that outside, water pumped out of the tank can be returned to the water table; thus its leakage into the tank causes only a temporary, minor local cone of depression of the water table when the tank is emptied of product.

The water surrounding a container may be salty or fresh, and sea water may be used to make up inadequate ground water. Other factors, such as the rights of other users of common ground water supplies or possible chemical reactions of "strange" water with the wall rock may, of course, limit the use of such "strange" water.

The tank may protrude above the water table, but only if its roof and its walls to a depth below the water table are impermeable to the product and its vapors. Accordingly, naturally or otherwise, the water table must be maintained above a definite level near or above the uppermost permeable part of the container.

Displacement Water Requirements

Underground storage tanks in most places will be unable to deliver stored materials by gravity to refinery or loading facilities, but displacement by water while "emptying" a tank can supply most of the pumping energy. With no vapor phase forming in the tank because pressure is maintained by incoming displacement water, there is no added tendency toward emulsification by water dripping through the vapor into the stored liquid. Accordingly, a supply of displacement water equal in volume to the stored material must be available as fast as the stored material need be emptied from the tank.

Other Requirements

The other requirements for Edholm containers are:

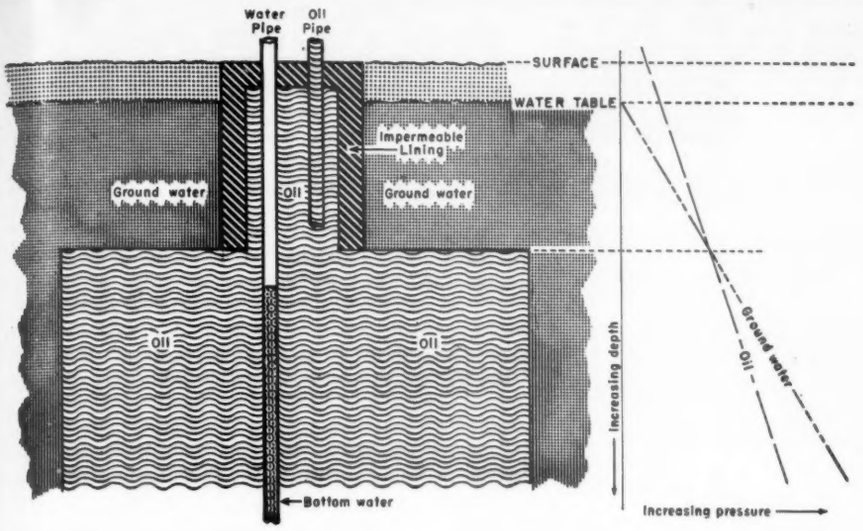


FIG. 4. Diagrammatic sketch of an Edholm container with lining.

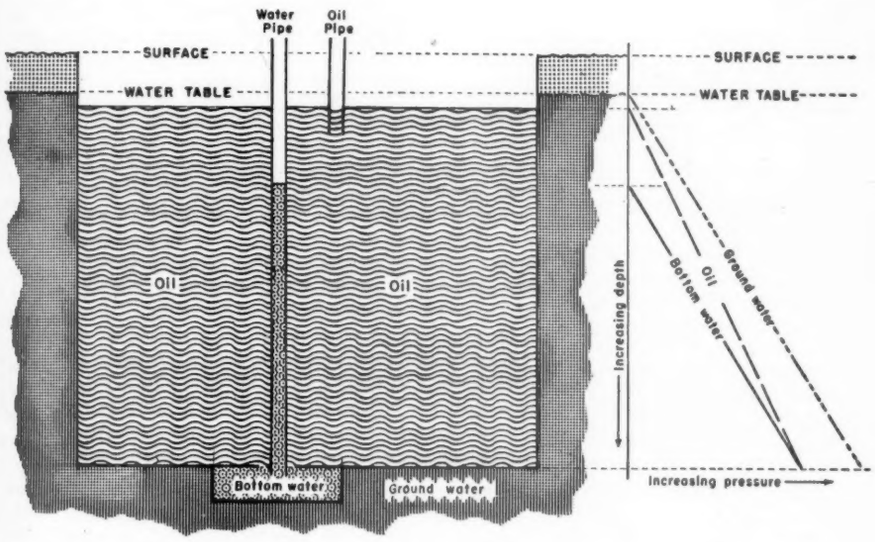


FIG. 5. Diagrammatic sketch of an open Edholm container full of low vapor pressure oil.

1. Pump capacity to empty the tank of product at the desired rate.
2. Pump capacity to maintain a constant bottom water level during storage and empty the tank of water at the desired rate of filling with product.
3. Automatic pump controls or caretaking personnel.

Closed Top Containers

The diagrammatic sketches (Figs. 1, 2, and 3) show an end elevation of a simplified closed container of about 50,000 bbl. This type of container is suitable for storing oils of any vapor pressure.

The container shown in the sketches is 30 ft wide and 100 ft high; its length (not shown) is 100 ft. The tank top is 20 ft below the surface, the bottom 120 ft, and the water table 10 ft.

At the right of each sketch is a pressure-depth diagram showing pressure at any depth of ground water, product, and bottom water. Water and oil pressures are shown to increase .433 psi and .303 psi per foot of depth, respectively. These figures correspond to the slopes of the curves from the vertical. The oil curve and the ground water curve diverge rapidly downward from the top of the tank where they have a common pressure (Figs. 1 and 2). The figure of .303 used for the oil curves is correct for a gasoline of .700 specific gravity (about 70 deg API). It would be .428 for a 15 deg API gravity oil and the oil curve would show little divergence from that of the ground water.

The three diagrams are of a tank with an unlined rock roof. As explained later, the top may be open under certain conditions.

In Fig. 1 the tank is full of oil. At the tank top the oil pressure, 4.33 psig, is exactly balanced by the ground water pressure. At the bottom, ground water pressure is 47.6 psig and oil presssure is 34.6 psig, a difference of 13.0 psi. Under the oil and balancing its pressure, the bottom water is forced into the water pipe to 40 ft from the surface. As the ground water pressure is greater than the oil and bottom water pressures, ground water will enter the tank through any connected pores or fissures, and run down the walls into the bottom water. Unless it is pumped out as it enters, it raises the bottom water pressure and the oil pressure and starts oil leaking out of the tank. However, merely by keeping the water in the water pipe pumped to or below the 40-ft level, the ground water seal is kept effective and the tank walls and roof oilproof.

In Fig. 2 the tank is half full of oil. Bottom water fills the bottom half, the oil-bottom water interface is at 70 ft, and their pressure at 70 ft is 19.5 psig. At this level the ground water pressure is 26.0 psig, a difference of 6.5 psi. Above the 70-ft level the pressure relationships are the same as when the tank was full, except that the water level in the waterpipe is now at 25 ft; it balances a lower oil pressure to keep the tank top pressure at or near 4.33 psig. The tank takes in less ground water than when full of oil, it is now half full of water, and there is a smaller average pressure differential to force water in.

The lowest pressure in the tank is the same 4.33 psig as when the tank was full of oil. Although the tank is now only half full of oil, no greater tendency to form a vapor phase over the oil exists now than before, and no air has entered.

In Fig. 3 the tank is empty of oil and therefore full of water. The oil curve and the bottom water curve have merged with the ground water curve. No pumping is necessary, of course, to maintain this condition; the tank may be unused indefinitely without deterioration and without any air entering it.

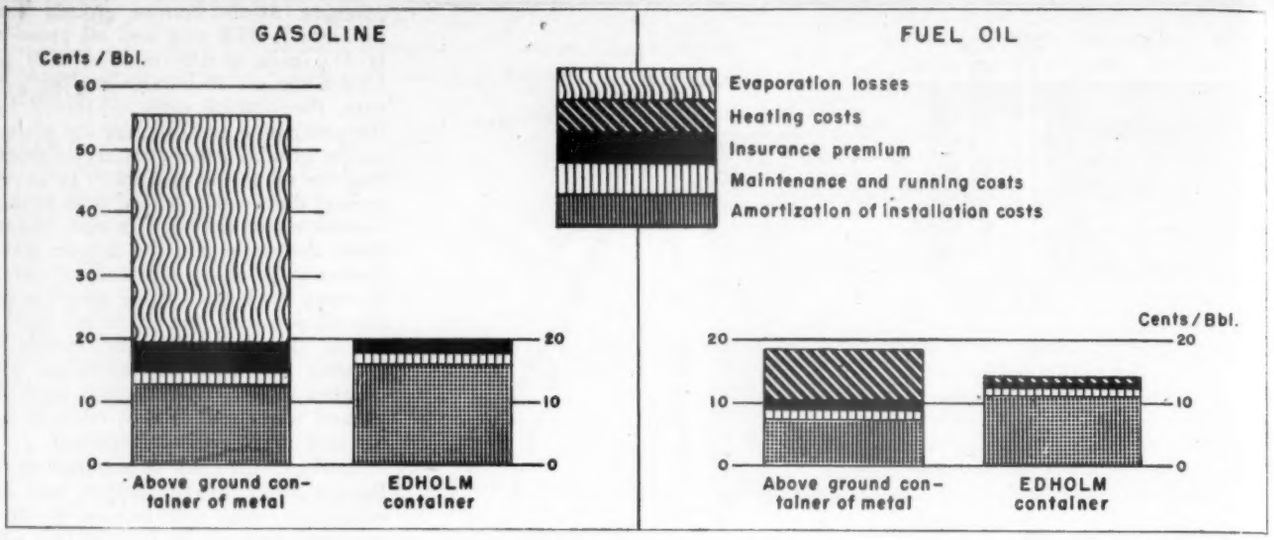
Preventing Vapor Formation

During actual operation the waterpipe level should be a little lower than shown to allow for the cone of depression and to give the ground water a little overpressure at the tank top. Depending on the vapor pressure of the oil, a vapor phase forms if the oil pressure at the tank top is lowered too much, and water will drip through the vapor. Greater flexibility can be provided by putting the whole tank further beneath the water table.

Sealed Top Containers

Lining the top part of the walls with steel plate, concrete, or other impermeable material also gives desirable flexibility and safety. Then the tank top need not be below the water table. The impermeable lining must extend downward only to the level where the maximum oil pressure to be used is slightly less than the minimum ground water pressure anticipated at that level.

If a high vapor pressure oil is to be stored, the lining must seal the roof as well as the upper



—Drawn by I. Dan Danziger.

FIG. 6. Annual storage costs in Sweden.

edge must be beneath the water table a depth equivalent to the oil vapor pressure so that no vapor may form. Or it can be necked down to a small enough internal area that evaporation losses are negligible and built high enough that the oil can rise in it to its equilibrium level.

The advantages of lining the top are not confined, however, to high vapor pressure oils. Even with a low vapor pressure oil such lining gives desirable flexibility in operating pressures, if it extends above the water table and above and below the highest and lowest oil-top levels respectively—and of course down and a little below the level where ground water pressure equals the maximum oil pressure.

Fig. 4 is a diagrammatic sketch that illustrates a container with a lining. The tank top is at the surface, the water table below it. The lined part is made as a small neck that acts as an oil sump when emptying the tank. Oil pressure in the lined part is higher than the ground water pressure, but the impermeable lining prevents leakage. Below the lining the ground water pressure prevents oil leakage. This container is suitable for high or low vapor pressure oils.

The larger the volume in the lined "sump" the less critical the constant near equality of water and oil pumping rates. When the tank is being emptied, oil pressure can be reduced until the vapor phase that forms in the neck almost reaches the lower end of the oil pipe before any addition to bottom water need be made.

The graph on Fig. 4 shows the oil to be under pressure at the surface, so that the tank will empty itself by gravity as it is filled with bottom water. The farther down the lining extends, the greater the oil pressure available to empty the tank without endangering the ground water over-pressure at any level in the unlined part.

Fig. 5 shows an open tank, one suitable for storing low vapor pressure oils. Such a tank holds no back pressure on the oil surface; it is simply storage at atmospheric pressure. The oil surface must be kept below the water table—the only operational requisite. No roof is necessary to prevent oil leakage, although, as with any other atmospheric pressure storage, a roof must be provided to keep out dirt, rain, and snow, and to reduce the fire hazard.

Present Edholm Containers

Two Edholm containers are in actual use in Sweden; a third is under construction. All are near Stockholm.

The largest is an ex-feldspar mine. It was sold as abandoned to the Swedish Government who, under Edholm's supervision, cleaned it of loose rock and ice and put it into operation as a fuel oil storage tank. It holds 1,040,000 bbl of oil below the water table and operates as a ventilated open tank, although it has an arching concrete roof high above both oil and ground water. Auxiliary facilities include an underground positive-head pump and filter room, underground heating room, water and oil pipe lines to docking facilities at the sea a mile away, and an elevator to the surface. The original owners mined out irregular lenses or pockets of feldspar occurring in a nearly vertical vein or zone. The tank shape is, therefore, a rough and irregular, nearly vertical slit about 260 ft deep. The wall rock is granite and gneiss, somewhat jointed and fractured. About 10 bbl of ground water seep in per day with 160,000 bbl of oil in storage. The oil stored is 20 deg API gravity. The pumps can handle 1900 bbl per hour oil out and sea water in. Although filters are provided in the pump room, they have never been used; no sediment or water is evident in the discharge line when oil is drawn from the tank. About 2,000,000 bbl have been stored in and delivered from the tank since its first use for storage in 1949.

In the course of his research on tanks, Edholm has built a pilot plant gasoline storage tank of about 113 bbl under his own property in Saltsjobaden, on the sea just out of Stockholm. It is in badly jointed gneiss, some of the joints or fractures being wide enough to stick a pencil into. The tank is closed and unlined. Ground water leaks into it at about 10 bbl per day. A batch of gasoline was pumped into the tank June 6, 1951; a measuring device sensitive enough to measure as little as a quart of shrinkage showed no loss on April 1, 1952, 10 months later. The gasoline is unleaded, 85 per cent cracked, 15 per cent straight run. Analyses of the gasoline made June 6, 1951, September 15, 1951, and March 4, 1952, showed no detectable changes in gravity, vapor pressure, gum content, sulfur content, water content, octane rating, or peroxide content. At the March, 1952, test the color had whitened somewhat. A faint aldehyde odor was detectable in the tunnel into which the excess bottom water is pumped. There is no other hydrocarbon smell.

Near the "million barrel" fuel oil tank, the Swedish Government is converting a similar but smaller abandoned feldspar mine for gasoline storage. It will operate as a sealed tank, but with a vapor phase above the gasoline. Its capacity will be about 190,000 bbl.

Costs

The cost of Edholm containers of 100,000 to 200,000 capacity dug in crystalline rocks in Sweden in 1952 is $3 to $3.50 per barrel of storage. Costs are much lower where the cavern is already available. The "million barrel" fuel oil tank, for example, including the purchase of the abandoned mine for $5000, cost 55 cents per barrel. Abandoned mines available for container storage in Sweden today will cost between $0.50 and $1.10 per barrel to buy and convert.

Corresponding steel surface tankage costs are $1.90 to $2.20 per barrel. The high price for steel tankage is the result of Sweden's current steel shortage; the same figure in 1949 was $1.20. None of these figures include pipe line and terminal facilities.

The National Petroleum Council Committee on Underground Storage, in its report approved by the Council on April

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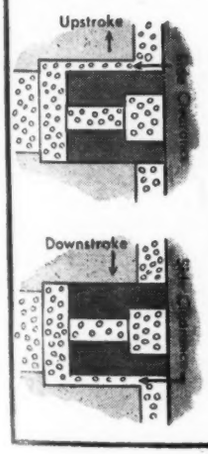

An ordinary oil control ring alternately acts as a valve plate against the upper and lower groove lands of the piston. On the upstroke of the piston, the ring seats on the lower land and the side clearance at the top fills with oil. On the piston's downstroke, the ring is seated against the top land and "squeezes" the oil out of the clearance past the ring. This "valving" action in an engine of average size and speed materially increases lub oil consumption.

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22, 1950, states that construction costs for mined cavern storage may vary between $2 and $8 per barrel in impermeable formations, not including preliminary exploration and testing. Testing here refers chiefly to the core drilling and sample study necessary to determine rock permeability and extent of fracturing. Exploration and testing to locate suitable rocks or unconsolidated sediments for containers should be minor in most parts of North America, as such geological knowledge is widespread and well publicized.

The preceding estimates are for comparatively small storage volumes. Costs go down as the size of storage goes up. Containers for more than 1,000,000 bbl should cost considerably less than the figures given above. Carefully made figures for a series of mined caverns totaling about 50,000,000 bbl at a depth of 1000 ft in limestone in northern Illinois show a cost of about 75 cents per barrel.

Although no figures for annual costs can be given for North America, where no Edholm containers are yet in use, the Edholm container's longer life and correspondingly lower amortization, virtual elimination of losses by evaporation, lower insurance rates, somewhat lower maintenance costs, and, in low-temperature areas, elimination of heating costs, make annual costs lower for Edholm containers than for aboveground storage in Sweden.

The container is not subject to corrosion, wear, or other deterioration. It should last indefinitely. Machinery and equipment will probably deteriorate at about the same rate as other equipment similarly used, and should be amortized accordingly, but the container itself—the major item of cost except where a pre-existing cavern is used — may be amortized over 50 years or even more.

In a container suitably adapted to the product to be stored, evaporation losses are negligible. Edholm's demonstration gasoline storage tank, in which instruments capable of measuring a change of as little as a quart have recorded no loss from 113 bbl of 63 gravity gasoline during 9 months, indicates that elimination of the evaporation losses common in aboveground storage represents a material lowering of annual costs.

No free air need be present in a closed container; the fire and explosion hazard in such a container is nil. An open-topped container at the surface would be damaged less by a direct bomb hit than would a steel tank, and would probably suffer little if any damage from a bomb hit near by. A container with its top 20 ft below the surface, with a strong roof and the space above the roof back-filled to the surface, would probably withstand a direct hit from anything less than a blockbuster. A container in solid rock 100 ft or more below the surface should be undamaged by even the largest bomb. For these reasons, both peacetime and wartime insurance on Edholm containers should be materially less than for aboveground tankage.

The Edholm container will not maintain itself. The roof—if it is roofed—and the lining—if part of it is lined—will from time to time require repairs and replacements. Pumps and pipes will require normal maintenance as in any other type of storage. The maintenance advantages are that the main body of the tank, the largest part of the apparatus, will require no painting and little or no other maintenance, and that no fire walls or fire-extinguishing equipment within the tank need be installed or maintained. These advantages should result in somewhat lower maintenance costs for an Edholm container than for a conventional tank of the same volume.

This storage is virtually constant-temperature storage the year around. Only in the coldest climates does the temperature vary seasonally below 20 ft from the surface. Tanks with their tops at this or greater depths can be expected, once thermal equilibrium is established, to maintain uniform temperatures of 40 to 50 F. In areas where heating of fuel oil tanks is required during the cold months, as in Canada and the northern United States, storage in Edholm containers would save most if not all of this heating cost.

Summation of Cost Considerations

Consideration of these various factors leads to the following conclusions:

(a) Where suitable pre-existing caverns such as mines or underground quarries are not available, and Edholm containers must be excavated, the initial cost of small and moderate-sized storage will be materially greater than for aboveground steel storage, but the initial cost of large-scale Edholm storage may approach or even be less than the cost of aboveground storage.

(b) Where suitable pre-existing caverns are available, the initial cost of Edholm storage will be materially less than the cost of steel storage.

(c) Annual costs of Edholm storage, including operating costs and amortization, should be materially less than for aboveground steel storage.

Suitable American Areas

Rocks and ground water conditions are favorable for Edholm containers almost everywhere. However, there are exceptions. In some of the Great Lakes states, the Gulf Coast of Louisiana, Texas, and Mexico, the Permian Basin of Kansas, Oklahoma, Texas, and New Mexico, and the prairie provinces of Canada, sedimentary salt formations or salt domes lie near enough to the surface to furnish almost unlimited storage in solution cavities. Wherever such cavities are possible, storage in them is probably cheaper and as safe as Edholm container storage.

In parts of the western states of the United States and Mexico, the water table is so far beneath the surface that Edholm container storage may not be economically feasible. For the most part these dry areas are sparsely inhabited, and the need for storage is small.

For the remainder of North America and United States possessions Edholm containers offer cheap, safe underground storage. ★ ★ ★

How to Select Sites for Underground Storage

Cooperation between geologists, contractors, and engineers in the field of petroleum together with civil and mining engineers is necessary to find and develop excavations

R. L. LOOFBOUROW*

KEEN interest in excavated underground storage, particularly for LPG, has brought a phase of mining into the petroleum industry. Sufficient work has been done to show that this type of storage has significant cost advantages as compared with surface pressure storage; it also furnishes some guidance for further work.

Steps generally taken in constructing underground excavated storage are:

1. Concept of site or sites at which storage would be desirable.
2. Examination of site or sites.
3. Construction underground and on surface.
4. Testing and charging.

This paper will discuss the second step, the aims of which are to determine before heavy commitments are made, if storage is feasible, and to obtain as much data as possible for planning, and for cost and time estimates.

Physical Properties of Rock

Physical properties limit the extent of rock excavations, the means which may be used in excavating, and the effectiveness of the excavations for storage. They cannot be changed. It is, therefore, of the greatest importance to choose suitable horizons for storage chambers, and to design accordingly. Although remedial measures may be taken where conditions are not entirely favorable, they add to cost. Two important physical requirements are stability and tightness of rock. These characteristics are commented on in the next two paragraphs.

A. *Stability.* Unless expensive artificial support is to be used, rock in which chambers are to be excavated must be strong enough so that openings will be permanently self-supporting. Too large an excavation will fail, even in the strongest rock, but the cost of excavating a given volume is generally least if the excavation is large. It is, therefore, essential to know approximately the maximum excavation that can be made without sacrificing stability. Further, if a sizable volume of storage is required, it may be economical to open a number of chambers arranging them to best advantage for mining while leaving pillars of undisturbed rock to carry the weight of overlying material.

*Manager, Mine Contracting Department, E. J. Longyear Company, Minneapolis, Minn.

B. *Tightness.* Perfection in nature is rare, and absolute impermeability in rocks is no exception. In even a "solid" or massive rock some cracks or joints are usual, especially if the rock is strong; softer rocks may yield plastically without cracking. Research is needed to develop practical means of sealing permeable rocks. To prevent or minimize leakage unless or until sealing techniques are proved, natural tightness is needed.

Novelty of This Examination

While this work is in some respects akin to foundation testing and some mining problems its introduces new problems and new combinations of problems. The whole operational technique is like the product to be stored—fluid. The next few years should see noteworthy improvements. The following outline is thought, at this juncture, to be comprehensive.

Outline of Examination

This outline is arranged in steps that may be overlapped. The early steps commit the least in time and cost. Succeeding steps need not be taken unless the results of the earlier steps are favorable. At the conclusion of each step, information may be summarized and recommendations made for further work.

A. *Reconnaissance of Selected Area Including Study.*

1. All available geology for general information on stratigraphy and regional structure; also all available physical description of rock to a depth of possibly 600 ft.
2. Facilities, including means of handling product, minimum space required for construction and permanent plant, utilities, land values, and labor conditions.
3. Topography, to determine best means of access to chambers, i.e., whether by shaft or by tunnel.
4. Local or national regulatory laws and requirements for approval of project by governmental agencies.

B. *Preliminary Drilling and Study.*

1. The object of preliminary drilling should be to add to general information by completely coring one preliminary hole located near the center of the proposed storage area. Observation should be made on core, preferably at the time of drilling and, subsequently, by laboratory studies; on the hole by pressure tests, for example; and on drilling performance and observations of drill operators to determine—
   a. Rock types, with special attention to hazards, such as the presence of coal, oil, gas or water.
   b. Physical characteristics of rocks with special attention to all rock weaknesses, permeability, water occurrence, mechanical strength of rocks in possible chamber horizons, stability of rocks on exposure to water and air, and properties which affect access to chamber horizon and mining.
   c. Chemical character of rocks, especially the effect of product on rocks and vice versa.
2. The above information should be summarized in a preliminary report with conclusions as to feasibility of storage and comments on the choice of various storage horizons, tentative arrangement, access, preliminary estimates of cost and time, and recommendations for additional testing. The estimates will be based on a tentative capacity or range of capacities, and approximate operating pressures.

C. *Detailed Drilling and Study.* Generally, it will be prudent to confirm the results obtained in the first hole by drilling a number of additional holes. The specific purposes of the additional study will be to check the results obtained in the first hole, to refine any procedures adapting them to the particular conditions found, and to determine the uniformity of the conditions over the area considered. To conclude this study, all information should again be reviewed, with such changes as may be appropriate in proposed design and estimates of cost and time.

Conclusion

A large part of the success of excavating underground LPG storage depends upon a proper appraisal of rock properties in advance of construction. The study of these properties, especially attempts to evaluate them in borings, is young. Improvements are to be desired and expected, particularly with the continued collaboration of geologists, contractors and engineers in the field of petroleum, mining and civil engineering.

* * *

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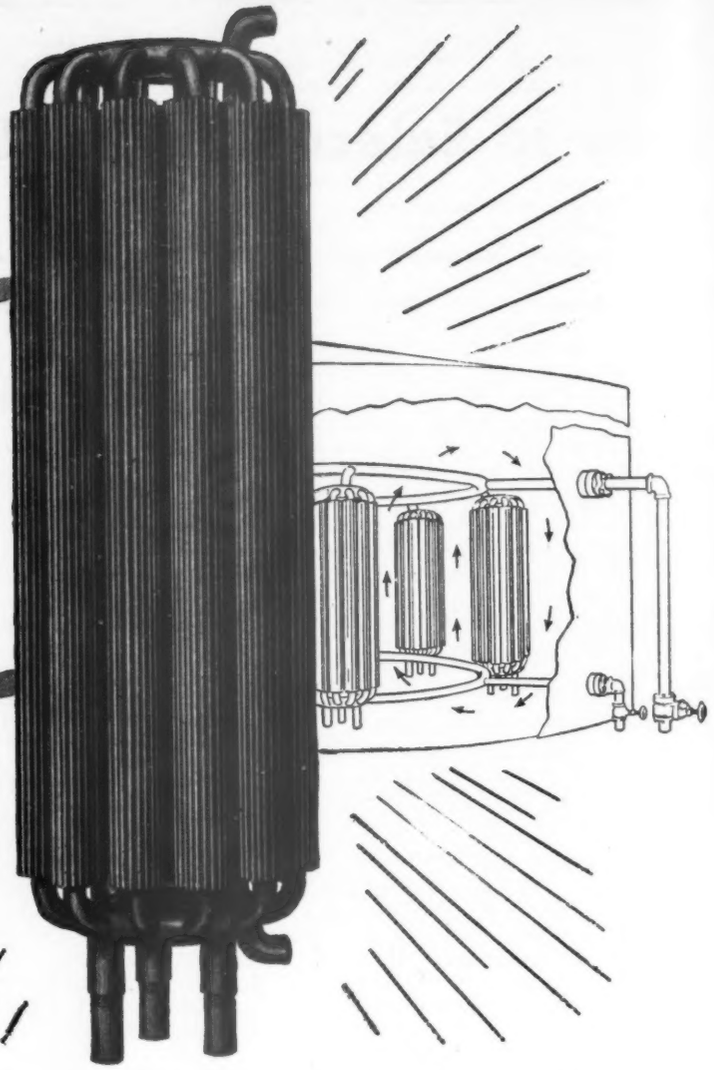

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Tank Farm No. 4	110 Heaters
Tank Farm No. 5	51 Heaters
Tank Farm No. 6	42 Heaters
Tank Farm No. 7	294 Heaters
Tank Farm No. 8	74 Heaters

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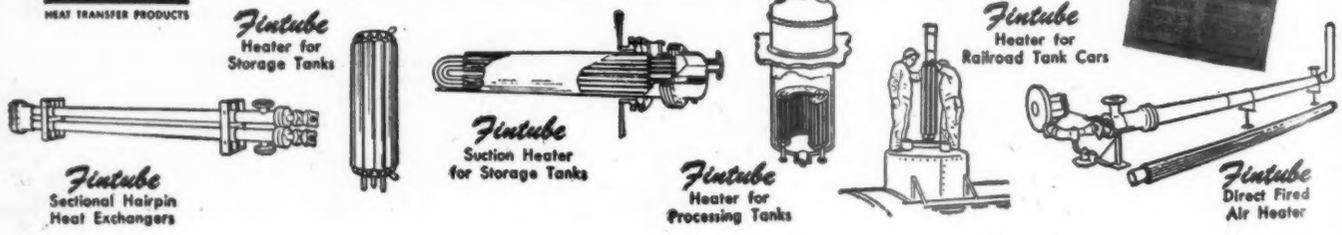

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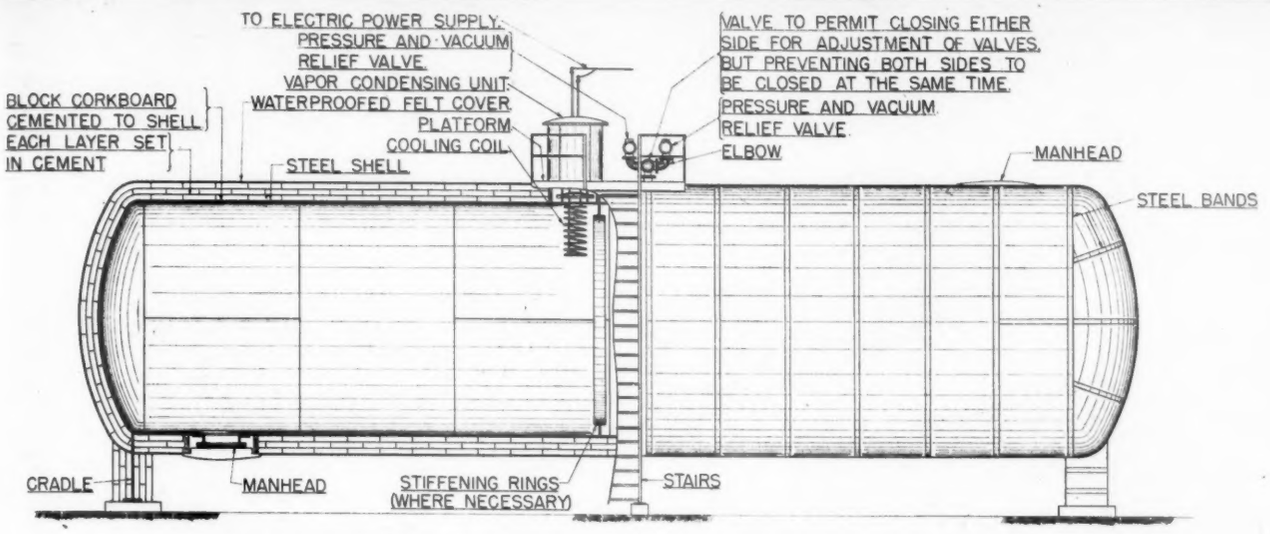


FIG. 1. A typical horizontal cylindrical container insulated for the storage of butane or other substances at temperatures down to 0 F and at pressures to suit process requirements.

What's Happening in Liquid and Gas Storage

Bulk storage tanks, designed to meet special needs, serve as reservoirs equalizing supply and demand in the oil industry

J. O. JACKSON*

STORAGE of petroleum and related products is of paramount importance to the petroleum industry. Bulk storage tanks serve as reservoirs equalizing supply and demand. Specially designed tanks store many products which are in the gaseous state at atmospheric temperature and pressure, and thereby conserve products which would otherwise be lost. Floating roofs, diaphragm roofs, and other methods of vapor storage and recovery are used in large installations for the atmospheric storage of volatile materials.

In the past decade the familiar flat-bottom, cylindrical oil storage tank has not changed greatly in appearance, but in the newer tanks there is an almost complete absence of stains from seepage in the tank plating. This change has been brought about by the almost universal adoption of welding in the construction of such tanks, and the fact that if a welded joint is once made tight it will usually remain so. Although welding has undoubtedly increased the strength and tightness of steel storage tanks, it has had the unexpected effect of producing tank shells more susceptible to tear and crack propagation. Because of the homogeneous nature of welded tanks, any defect, such as a slit or tear occurring during the testing or use of the tank, has a tendency to rupture over a greater distance than in a riveted tank. This is because of the lack of riveted seams to serve as stoppers for the propagation of cracks. This characteristic makes it important to design and construct welded tanks so that stress raisers, such as cracks, nicks, incompletely penetrated welds, unfused roots, and other such defects, are reduced to a minimum. It has been found that the use of butt joints with complete penetration, and careful attention to details to provide smooth or streamlined stress transfer between adjoining members, and the avoidance of rough burned plate edges in stressed members contribute to the safety of these structures.

During the past decade much study has been devoted to the properties of steel which determines its notch toughness or resistance to the propagation of cracks and tears. Many tests have been devised to compare the resistance to brittle failure of one plate steel with another. Most of these tests produce good comparative results, but it has not been possible to reduce such measurements to an absolute parameter which may be used to select the quality of steel necessary for a particular storage installation. It is generally agreed that brittle failures may be avoided either by the use of tough steel, by control of the intensity and rate of application of the impact loading on the structure, by constructing the vessel very carefully so that stress raisers and other points of incipient failure are avoided, or by a judicious combination of each of the above qualities in suitable amounts. The working stresses in flat-bottom gravity storage tanks have become almost universally standardized in accordance with the specifications of the American Petroleum Institute.

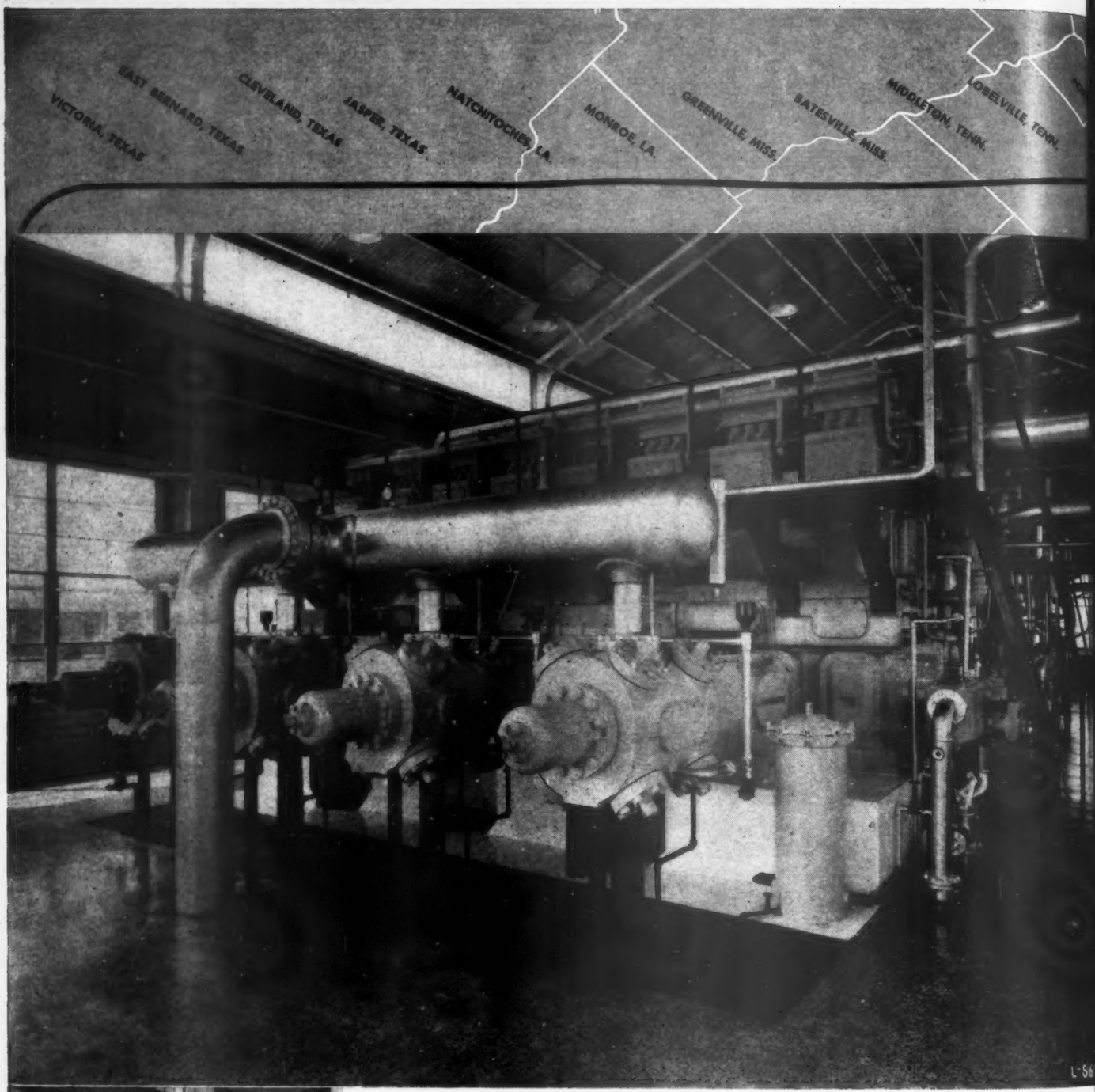
A look into the future construction of steel storage tanks would probably divulge an increased use of automatic welding, more streamlined stress transfer details, more stress relieving, either by heat or by prestressing during testing, to reduce the effects of weld shrinkage and locked-in stresses.

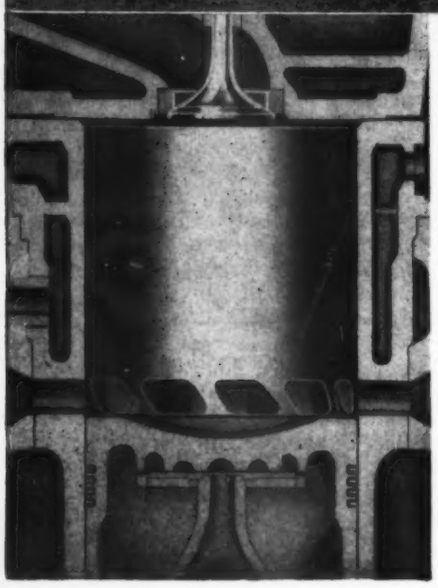
A considerable amount of research work has been done on the storage of various commercially important substances. The Chemical Storage Fellowship of the Mellon Institute, in Pittsburgh[1], has prepared reports on the storage of the following substances:

Acetaldehyde, Acetic acid, Acrylonitrile, Aluminum fluoride, Ammonia, Ammonium nitrate, Bauxite, Butadiene,

*Vice president in charge of research and engineering, Pittsburgh-Des Moines Steel Company, Pittsburgh, Pennsylvania.

EXCLUSIVE





THREE WORTHINGTON 1,600-HP UTC ENGINE COMPRESSORS at Tennessee Gas Transmission Co., East Bernard Station. Installation includes five units now in operation. All engines use Worthington's Uniflo through-scavenging system, a design thoroughly proved by years of research by Worthington engineers.

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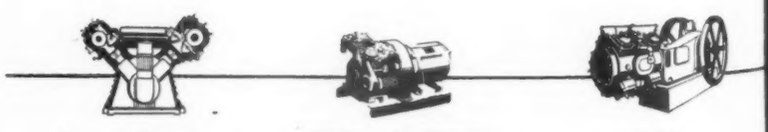

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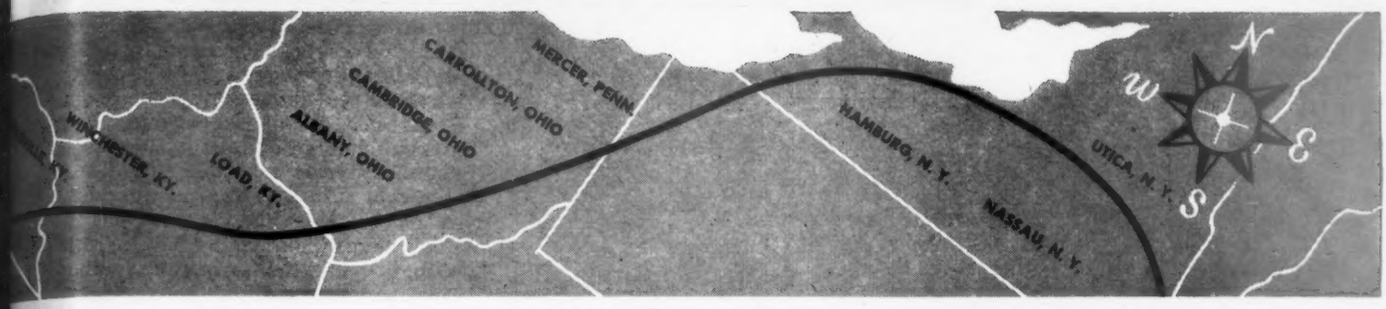

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46 Worthington UTC Engine Compressors help pump 1,250,000,000 cu ft a day

All along the Tennessee Gas Transmission Company line, from the Gulf Coast to the New England states border, you'll find Worthington UTC gas-engine compressors on the job.

At last report, more than 1,250,000,000 cu ft of gas was being sent through the line daily. A total of 46 Worthington UTC engine compressors are now installed at eight different compressor station locations.

All these UTC units use the Worthington *Uniflo timed-scavenging method*—one big reason for the smooth performance they give. Uniflo scavenging assures a "clean sweep" of burned gases.

While built primarily for pipeline gas compression, the UTC is ideal for many other jobs such as: pressure maintenance on oil wells; varied service in natural gasoline plants; on solvent extraction, vapor recovery, recycling and stabilization of gases in oil refineries; in petro-chemical processing of products made from natural gas under pressure; and in many refrigeration applications.

If your process requires gas compression and you have a suitable gas available for fuel, the Worthington Uniflo UTC can do the best possible job for you.

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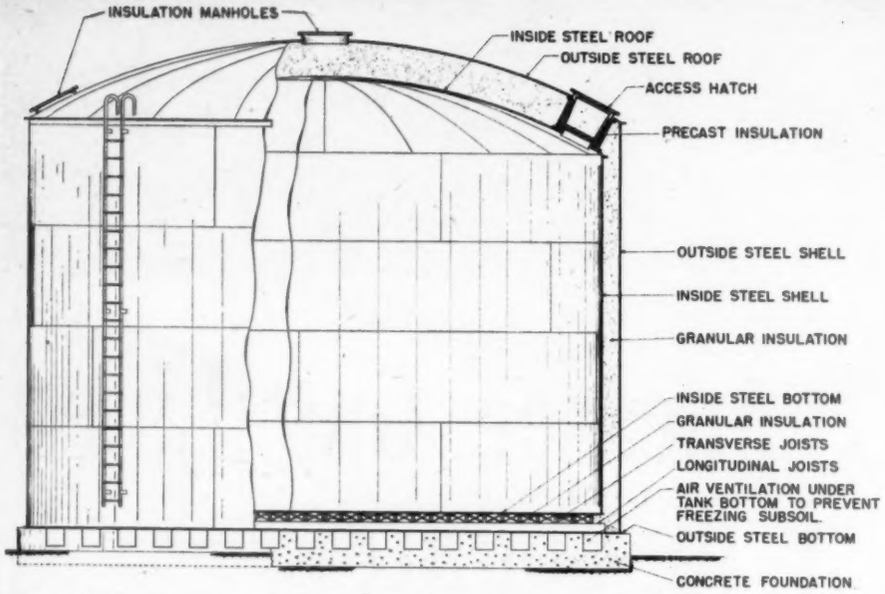

FIG. 2. Insulated tank 31 ft diam by 20 ft high, built at Wright Field, Dayton, Ohio, for storage of calcium chloride brine, varying in temperature from plus 120 F to minus 40 F. Total capacity is 112,000 gal. Insulation is 12 in. on side walls, 24 in. on roof.

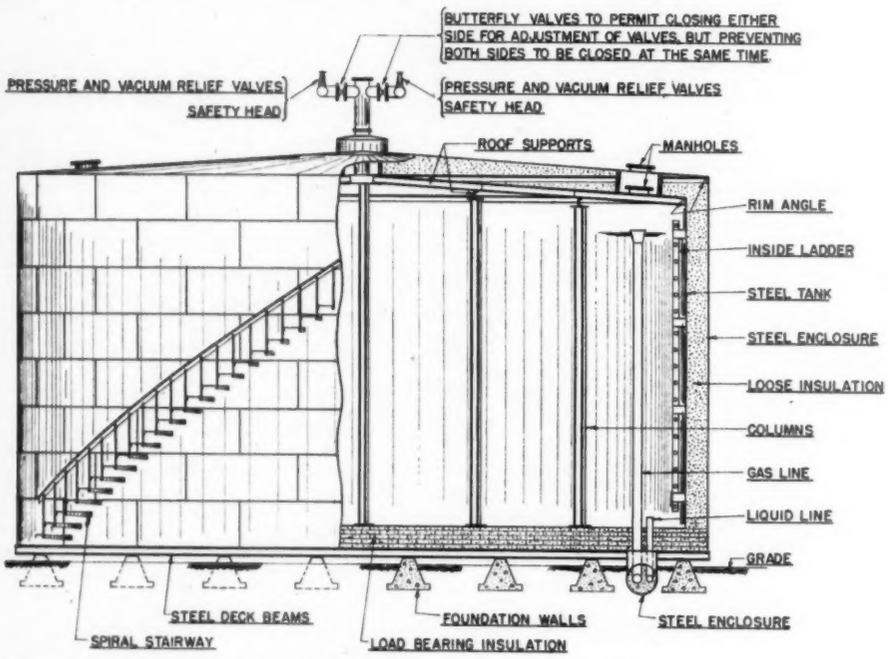

FIG. 3. Typical double steel shell insulated cylindrical container for storage of propane or other substance at temperatures down to 100 F below zero and at atmospheric pressure.

Butadiene and isobutylene, Normal butane, Butene-1, Butene-2, Trans-butene-2, Benzaldehyde, Calcium chloride, Carbon dioxide, Castor oil, Caustic soda, Chlorine, Coconut oil, Coke, Cryolite, Ethyl acetate, Ethyl alcohol, Fluorspar, Formaldehyde solutions, Freons, Gas oil, Gasoline, 6.5 R.V.P. gasoline, Hydrofluoric acid, Anhydrous hydrogen, Hydrogen peroxide, Isobutane, Isobutylene, Magnesium oxide, Methanol, Methyl chloride, Nitric acid, Palm oil, Propalene, Propane, Common refrigerants, Soda ash, Sperm oil, Styrene, Sulphur dioxide, Sulphuric acid, Turpentine, Vinyl chloride.

These reports contain the chemical and physical properties of the substances at different temperatures and pressures, with particular reference to storage problems, such as their ability to corrode tank metals and the effect of tank metals on the substances being stored. The reports include recommendations for suitable materials for the containers, gaskets, pipes, valves, and other accessories; the range of temperatures and pressures which are most economical for storage; and methods of safely handling such substances. Data on production, uses and toxicity is also included.

Copies of these reports are available.[2]

One of the most commercially important recent developments of new storage tanks is the hermetically-sealed insulated tank[3] for the refrigerated low-pressure storage of volatile substances. For many years steel tanks have been lagged or insulated to reduce the heat transfer between the contents and the atmosphere. Such lagging may be satisfactory where the temperature differences are not great or where special care is used to maintain a permanently tight vapor barrier. It has been found that it is very difficult to maintain moisture-tight vapor barriers in lagged insulation over long periods of time, even with moderate temperature differences. This difficulty has led to the development of the double-wall steel tank in which the space between the two air-tight steel walls is filled with either a solid or granular insulating material of proper thickness and characteristics for the particular installation. The two steel walls are electrically welded bottle-tight, and if properly made will remain tight indefinitely. Designs are available for a complete range of types, sizes, pressures, and temperatures. Insulated tanks are especially suited to the storage of such substances as ammonia, ethylene, butane, propane, methane, oxygen, nitrogen, and other substances having high vapor pressure at normal ambient temperatures. Materials are available for the inner shells remaining ductile at temperatures down to several hundred degrees below zero Fahrenheit. The substances stored may be either artificially refrigerated using cooling coils inside or outside the storage tanks, or they may be self-refrigerated by compressing, condensing, and returning the evaporated discharge to storage.

Fig. 1 illustrates a typical horizontal cylindrical container insulated for the storage of butane or other substances at temperature down to zero degrees Fahrenheit and at pressures to suit process requirements. Fig. 2 illustrates an insulated tank 31 ft in diameter and 20 ft high, built at Wright Field, Dayton, Ohio, for the storage of calcium chloride brine varying in temperature from plus 120 F to minus 40 F. Total capacity is 112,000 gal. Insulation is 12 in. thick on side walls, and 24 in. on roof. Fig. 3 illustrates a typical double steel shell insulated cylindrical container for the storage of propane or other substances at temperatures down to 100 F below zero and at atmospheric pressure. Fig. 4 illustrates a double steel shell insulated spherical container for the storage of liquefied natural gas at a temperature of minus 260 F and a pressure of 5 psig.

Spherical tanks have been built for many years and their advantages of minimum shell thickness for given size and pressure are well known. One of the inherent disadvantages of the spherical shape, however, has always been the amount of scrap removed in trimming rectangular plates to form the orange peel shaped plates from which the usual spherical tank is made. A recent development has resulted in considerable eco-

nomy in the construction of spherical tanks. This development has been named the Icosasphere.[4] This new sphere has been described in many articles.[5] It is based on the formation of the shell of a sphere from five pieces each containing four equilateral spherical triangles projected from the center of the sphere along the sides of the fundamental twenty equilateral plane triangles of the inscribed icosahedron. As the icosahedron can be built from five parallel-sided plates each containing four adjacent equilateral triangles, without any scrap loss, it follows that a spherical tank built from five plates each containing four equilateral spherical triangles arranged in a similar way should have a minimum scrap loss. It has been demonstrated that this arrangement results in a lower scrap loss, shorter total length of welded seams, and a lower erection cost than the usual orange peel design.

Fig. 5 illustrates three Icosaspheres recently completed for the National Advisory Committee for Aeronautics, at their Langley field, Virginia laboratory. The butt welded spheres are 31 ft 1 in. inside diameter with a metal thickness of 1¼ in. for the storage of compressed air at a pressure of 160 psi. Fig. 6 shows a picture of a 32-ft diameter Icosasphere under construction at the U. S. Naval Laboratory at Carderock, Maryland, which illustrates the rectangular shape of the plates used to form the shell of the sphere.

Another development in storage tanks of importance in the storage of liquids or gases under high pressures is the caterpillar or intersecting sphere tank.[6] Although a spherical tank has the minimum thickness of any possible shape for a given size and pressure, as the size of the tank increases the thickness of the steel shell also increases. Because the thicknesses of shells of unstress-relieved pressure vessels is limited by usual codes to 1¼ in., the maximum diameter of large spherical tanks for pressure storage is correspondingly limited. The intersecting sphere tank is formed of a number of spherical segments or zones joined together at their planes of intersection and arranged in any desired pattern. For example, the caterpillar tank makes use of a number of partial spherical shells arranged along a straight line axis. A steel diaphragm is placed in the plane of each intersection of adjacent spherical shells, and resists the radially outward forces resulting from the shell stresses. It has been proved that if the diaphragm is designed for the same unit stress as the spherical shells, the ratio between the volume of the tank and the weight of the shell plus the diaphragm will be exactly the same as the ratio of the tank volume and the shell weight of

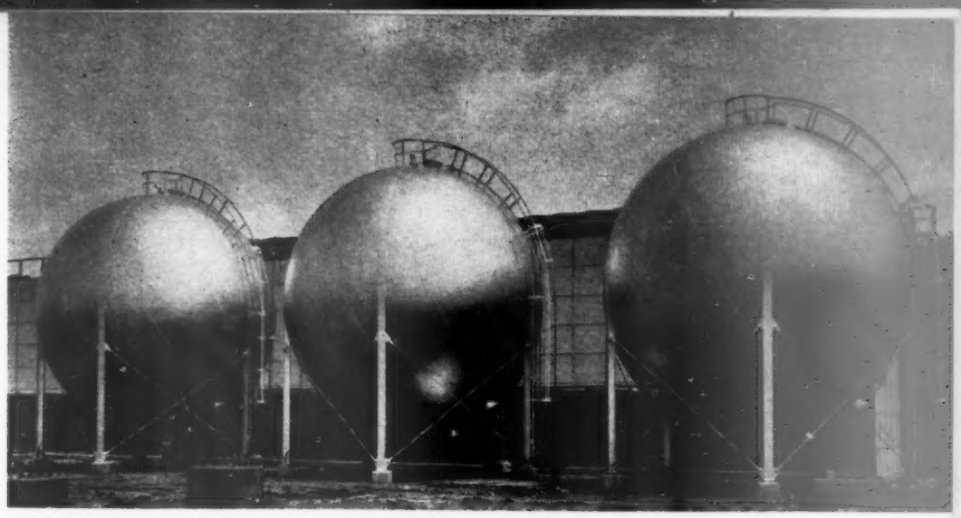

FIG. 5. Three 31-ft 1-in. inside diameter Icosaspheres for 160 psia compressed air storage at National Advisory Committee for Aeronautics, Langley Field, Virginia Laboratory. Butt-welded plate steel shell is 1¼ in. thick.

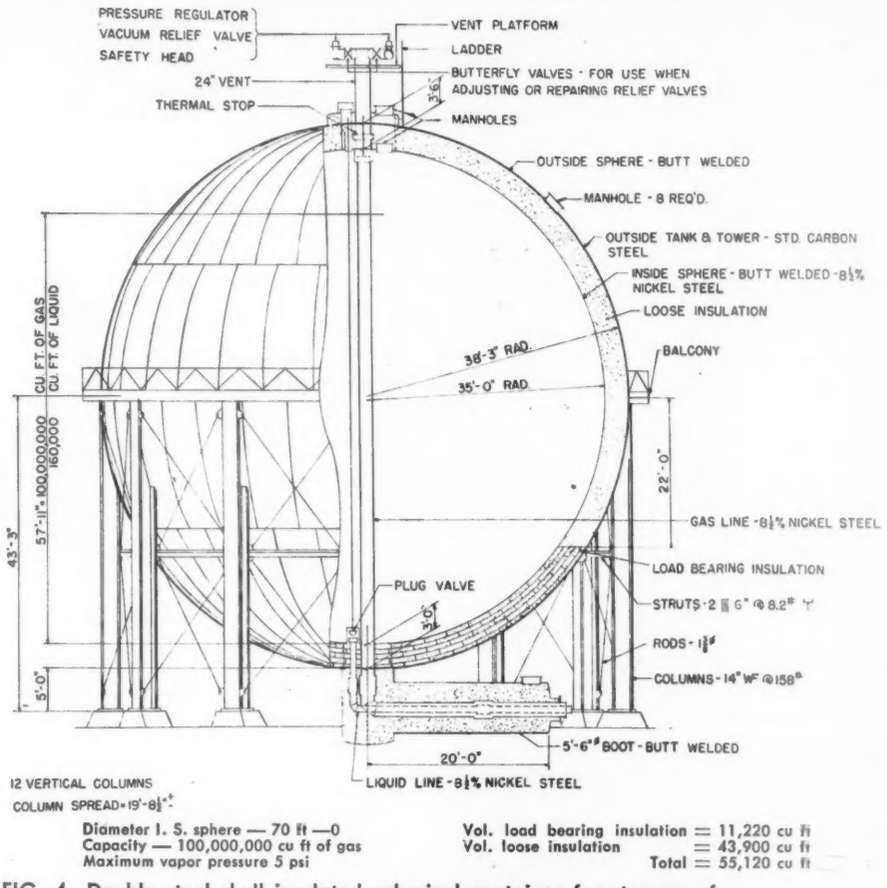

FIG. 4. Double steel shell insulated spherical container for storage of liquefied natural gas at a temperature of minus 260 F and a pressure of 5 psia.

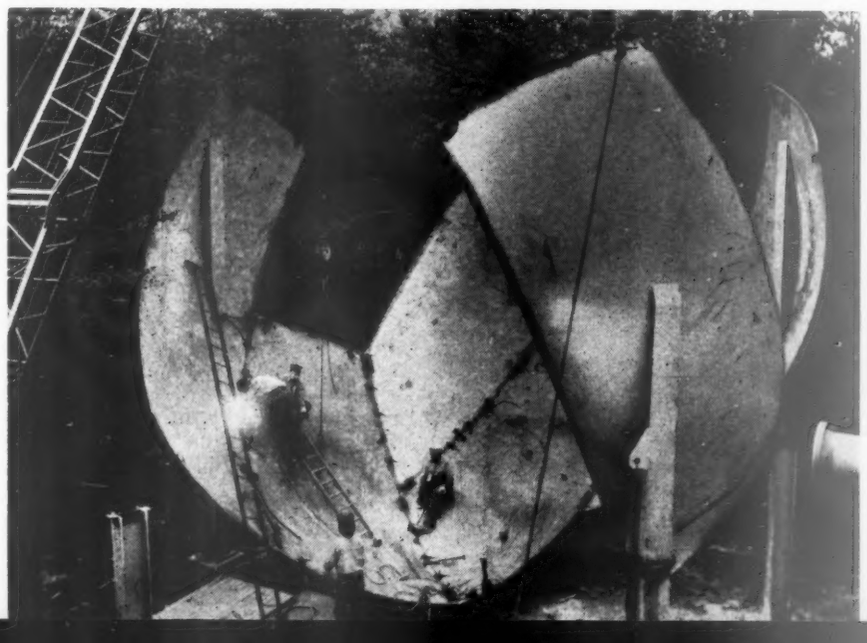

FIG. 6. A 32-ft diam Icosasphere under construction at Carderock, Maryland laboratory of the U. S. Navy illustrates rectangular shape of plates forming shell of sphere (Left.)

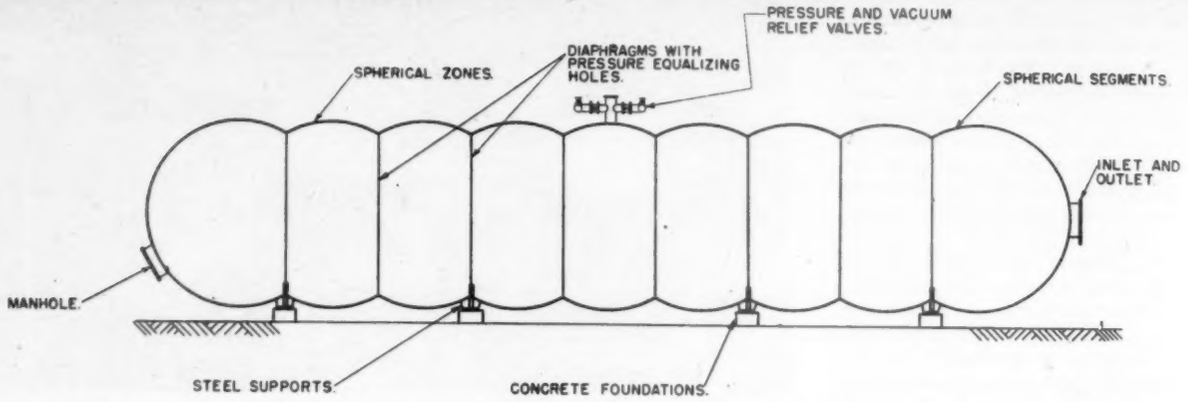

FIG. 7. Caterpillar tank for storage of compressed air at a pressure of 500 psi. Inside diameter of spherical shells is 9 ft 11 in. and the thickness of plates and diaphragms is 1¼ in.

a single sphere without any diaphragm designed for the same volume and internal gas pressure. It is interesting to note that if the diameter of the diaphragm is made 0.86603 times the diameter of the sphere, the thickness of the diaphragm will be the same as that of the spherical shell.

Caterpillar tanks are finding increasing use in the storage of liquids and gases at high pressure. Fig. 7 illustrates a caterpillar tank for the storage of compressed air at a pressure of 500 psi. The inside diameter of the spherical shells is 9 ft 11 in. and the thickness of the plates and diaphragms is 1¼ in. Caterpillar tanks may be racked to form assemblies of any desired height. Intersecting sphere tanks may be built in other forms such as toroids to suit particular layouts.

Since the early part of this century the familiar elevated tank consisting of a cylindrical tank shell with a hemispherical bottom and cone roof on a steel tower has been a familiar landmark in the skyline of almost every city and village throughout the country. Designs for hemispherical bottom tanks kept pace with requirements for larger and larger storage volumes until tanks of about 1,000,000 gal were built. Tanks of this capacity were from 50 to 60 ft in diameter and with a hemispherical bottom the range of head often became 50 ft or more. This large variation in head between a full and empty tank was undesirable because of the resulting variation in water pressure and lack of effectiveness in fighting fires as the tank emptied. The requirement for a lower range of head resulted in the development of tanks with elliptical bottoms. Then the double ellipsoidal tank with water stored in the elliptical roof was developed. For tanks of extremely large capacity the requirement for low head ranges was met by the toroidal and the radial cone designs which are still in use. Recent developments in elevated storage tanks have included streamlining and improving their appearance. Tubular columns have been used to an increasing degree to replace the built-up and rolled structural columns of the past. The advantage of the tubular column is that it may be made with a larger radius of gyration more economically than a built-up structural column; and with the larger radius, high towers may be built with a fewer number of panels. This results in a saving in weight and cost because of the elimination of struts and diagonals. It follows that if the radius is increased the metal must be thinner and thus more column area is exposed to corrosion. It has been found that if tubular columns are hermetically sealed, corrosion on the unpainted interior will not progress. The exterior surface area, although it may be greater than that of a rolled column, is easier to maintain because it is smooth and easily painted.

FIG. 8. One million gallon 88-ft diam welded obloidal water tank on a steel tower 88 ft high for water department of Fort Worth, Texas.

One of the outstanding developments in elevated tank shapes of recent years is the obloidal elevated tank.[7] The shell of this tank has the shape of an oblate spheroid formed by the revolution of an ellipse about its short axis. Fig. 8 illustrates one of two identical one million gallon welded obloidal tanks with 25-ft head range recently built for the city of Fort Worth, Texas. These structures could have been built with tubular columns, but in this design it was felt that the rolled columns were functionally preferred as they merge with the elliptical rings extending vertically around the tank shell to form supports for the tank roof and bottom. Some economy results from the fact that the vertical elliptical supporting rings are partially continuous. The bottom plates sag between the elliptical rings greatly reducing the thickness which would be required if the bottom were made a surface of revolution. It is believed that the obloidal tanks has the most pleasing appearance of any of the available types of large elevated steel tanks.

It can be confidently stated that steel tank design can and will be developed to furnish economical storage for any type of product and conditions of storage for which there may be future demand.

References

1. The Chemical Storage Fellowship of the Mellon Institute of Industrial Research is sustained by the Pittsburgh-Des Moines Company for the purpose of doing research work on storage tanks to increase their efficiency, life, and effectiveness and to lower their cost.
2. Copies of the research reports of the Chemical Storage Fellowship may be obtained by addressing the Fellowship, care of Mellon Institute of Industrial Research, 4400 Fifth Avenue, Pittsburgh 13, Pennsylvania.
3. Hermetically sealed insulated tanks are manufactured under patents owned by the Pittsburgh-Des Moines Company, Pittsburgh 25, Pennsylvania.
4. The Icosasphere is manufactured under patents owned by the Pittsburgh-Des Moines Company, Pittsburgh 25.
5. Articles describing the Icosasphere:
   Pittsburgh-Des Moines Steel Company. Research Report No. 7815-1, "The Icosasphere," by J. O. Jackson.
   "Steel," December 19, 1949, page 100.
   "American City," January 1950, page 157.
   "Steelways," January 1950, page 18.
   "Welding Engineer," March 1950, page 17.
   "Welding Journal," February 1950, page 103.
   "Business Week," December 3, 1949, page 25.
   "Engineering News Record," April 13, 1950, page 74.
   "Chemical and Engineering News," May 22, 1950, page 1750.
   "Iron Age," November 17, 1949, page 92.
   and many others.
6. The Caterpillar or intersecting sphere tank is manufactured under patents owned by the Pittsburgh-Des Moines Company, Pittsburgh 25.
7. The Obloidal elevated tank is manufactured under patents owned by the Pittsburgh-Des Moines Company, Pittsburgh 25.

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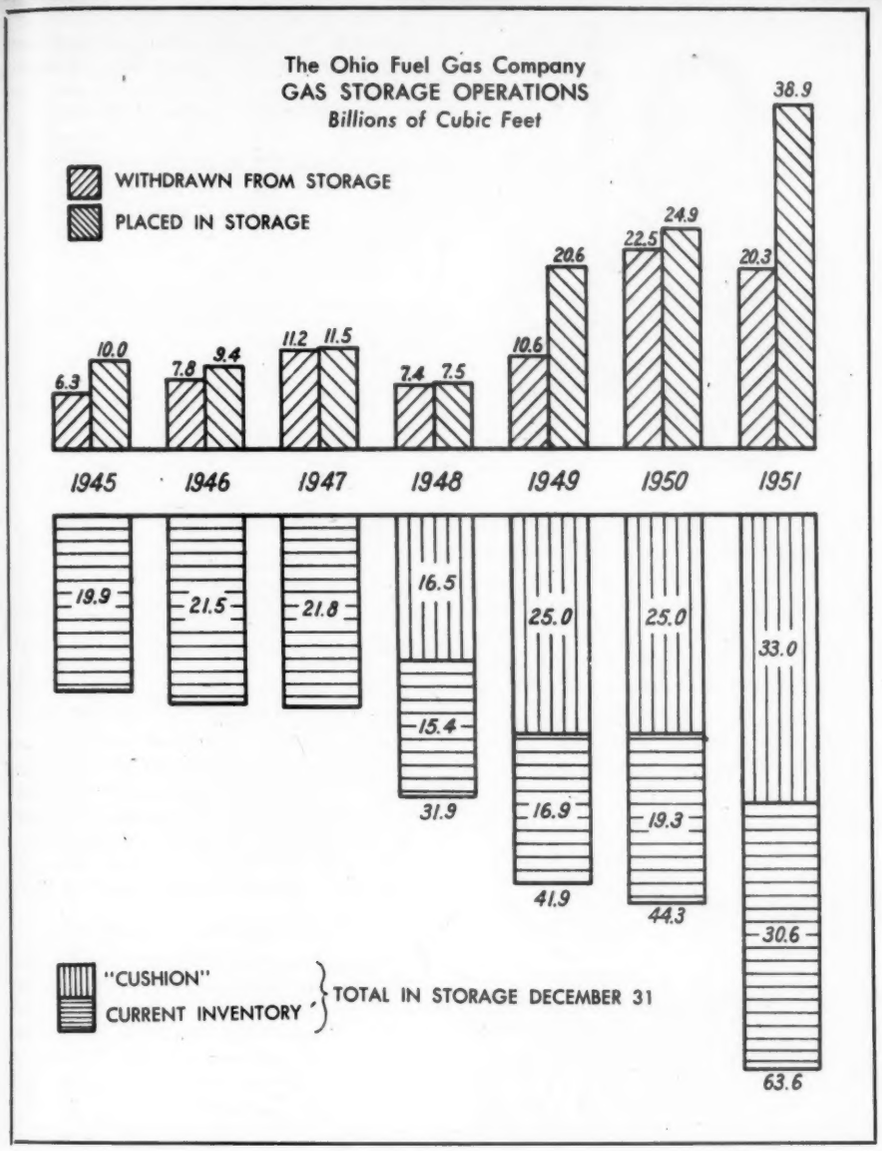

Gas Volume at Command

Underground storage expansion of Ohio Fuel Gas protects consumer in wide demand fluctuations

LATEST report on reserves made by the American Petroleum Institute and the American Gas Association indicates that Ohio leads all other states in the quantities of natural gas held in underground storage. A major role in the build up of this lead has been played by the Ohio Fuel Gas Company, a pioneer in the program of using depleted and partially depleted pools as vast containers for storage gas.

Ohio Fuel's activity and interest in underground storage are reflected by its greatly expanded deliveries. In the past 6 years, the company has increased deliveries by 90 per cent, started delivering gas to 87,000 new customers, and provided gas heat for over a quarter of a million more homes. Gas heat customers in Ohio Fuel's 49-county territory now number 315,000 compared with 50,000 in 1946.

EXCLUSIVE

Because of the large volumes of gas involved and the wide variation between summer and winter requirements, underground storage is the company's only means of accepting gas available from outside sources during summer months to assist in serving increased requirements during the winter.

The company initiated its underground storage operations in 1936 with one project in south-central Ohio, called the Benton area, and one in the north-central part of the state, called the Weaver area. Facilities were gradually expanded until in 1941 there were three projects in operation in each of these areas. During 1941 the company pumped about 7 billion cubic feet into these projects and attained a maximum stored volume of 17 billion cubic feet.

During World War II and immediately after it, shortages prevented any appreciable increase in gas requirements, supplies or facilities. But in 1946, about 9 billion feet were placed in storage and the maximum stored volume reached 24 billion feet. Since that time the unprecedented demand for natural gas as a fuel for space heating and the importation of large volumes of gas from the Southwest through long distance transmission lines have made rapid expansion of the company's storage facilities a necessity. During 1951, approximately 39 billion feet were placed in storage and the maximum stored volume reached 67 billion.

Storage Supplies Half

In illustrating the importance of storage in Ohio Fuel's operations, it has been pointed out that on December 16, 1951 — the highest demand day in the company's history — withdrawals from storage were more than 500,000,000 ft. That was 50 per cent of the company's total deliveries for the day.

Ohio Fuel now has in operation a total of 22 projects or storage units in five storage areas. These areas, in addition to Benton and Weaver, are known as Knox, Pavonia, and Wellington. The estimated total potential capacity of the five is 112 billion cubic feet. The company estimates that their capacity is about 10 billion feet short of what will be needed in storage by the fall of 1954. For that reason, authorization has been asked from the Federal Power Commission for the initiation and development of two additional areas.

The Benton and Weaver areas—those begun in 1936—are Ohio Fuel's largest. Benton is composed of 240 wells in 8 storage pools and its ultimate daily deliverability is estimated at 500 million cubic feet, assuming an ultimate capacity of 35 billion cubic feet. Weaver's ultimate deliverability is slightly greater—575,000,000—as is its ultimate capacity, estimated at 46 billion. It has 235 wells in 5 pools. Well depth in all areas is between 2400 and 3000 ft.

Smallest of the five areas is Knox, begun in 1945, and composed of one pool containing 33 wells. Its ultimate capacity is estimated at 3 billion. This small pool is expected to provide a daily deliverability of 60,000,000. In the two remaining areas, Pavonia is expected to

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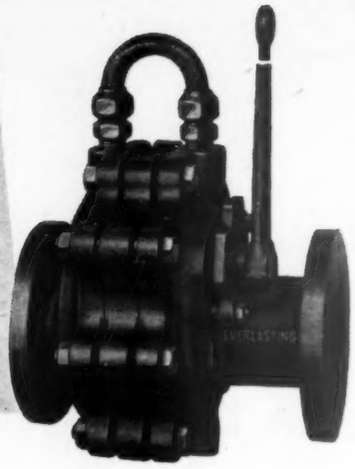

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TABLE 1. Underground storage program of the Ohio Fuel Gas Company

RESERVOIR DATA SUMMARY

Storage area	Year begun	Ultimate acres	Ultimate daily deliverability*
Benton.....	1936	18,000	500
Knox.....	1945	2,000	60
Weaver.....	1936	23,000	575
Pavonia.....	1951	12,000	225
Wellington...	1947	20,000	375

* In millions of cubic feet.

Storage area	Ultimate capacity†	No. wells 10/1/52	No. pools 10/1/52	Depth
Benton.....	35	240	8	2,400
Knox.....	3	33	1	3,000
Weaver.....	46	235	5	2,600
Pavonia.....	17	60	2	2,600
Wellington...	15	185	6	2,400

† In billions of cubic feet.

COMPRESSOR STATIONS USED IN CONNECTION WITH UNDERGROUND STORAGE

Storage areas	Location	Horsepower
Benton.....	Southwestern Hocking County	2,490
Knox.....	Southeastern Knox County	800
Weaver.....	Southeastern Richland County	11,650
Pavonia....	Southeastern Richland County and Southwestern Ashland County	5,300
Wellington..	Southern Loram County	3,200
		23,440

Ohio Fuel is spending about $5,000,000 on expansion of underground storage in 1952.

have an ultimate capacity of 17 billion with a daily deliverability of 225,000,000, and Wellington's ultimate capacity is estimated at 15 billion and its daily deliverability at 375,000,000. Pavonia was started in 1951; Wellington in 1947.

Horsepower Important

A necessary and important facility which must be provided in developing storage areas is the compressor station. By the end of 1952, Ohio Fuel will have compressor units with a total of 23,440 hp in its storage areas. These are distributed as follows: Weaver, 11,650; Pavonia, 5300; Benton, 2490; Wellington, 3200, and Knox, 800. (Pavonia compressor station is not now being used for storage gas exclusively). * * *

NPC Makes Storage Report

The National Petroleum Council's Committee on Petroleum Storage Capacity will release a new report December 9 after a meeting of the council in Washington. The NPC has been a leader in the study of storage of all kinds and specially underground storage. Its report of April 22, 1952, is probably the most comprehensive yet made. It was made under H. S. M. Burns, president of Shell Oil, as general chairman, and was carried out by a technical subcommittee under the chairmanship of B. F. Hake of Gulf Oil Corporation and Secretary S. Stokes Tomlin, Jr. of Turck, Hill and Company, Inc.

Upon recommendation of the committee the report was given widespread distribution throughout the oil industry.

The committee also pointed out the prevailing interest in underground storage and reported that a quick survey indicated there was in operation or under construction underground storage facilities with a capacity of about 7 million barrels. These facilities were mainly for liquefied petroleum gases.

Underground Storage of Hydrocarbons

The earth's natural structure has been utilized economically in recent years as a container for large volume products

GAINES H. BILLUE

MAN has long been taking oil and gas from the underground formations, but only in the last few years has he been able to store it back under the ground for immediate availability and future use. With underground storage the gas industries have virtually moved gas fields from far away places to points of consumption. Those who are dealing with liquid hydrocarbons find that a tool is developing to meet a demand long needed, one that is safe, abundant, and economical for the storage of liquid hydrocarbons.

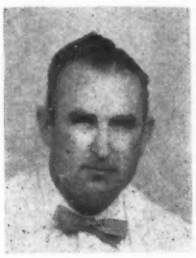
During the early stages of petroleum development the storage containers advanced from wooden stave tanks to steel tanks. As the industry progressed, however, vapor pressures above atmospheric pressures were developed. Many crudes were discovered that contained hydrogen sulfide and other compounds, which made them highly corrosive. Also, the inevitable happened — storage was at a premium and today storage costs, particularly above atmospheric pressure, are so great that it may not be economical to store off-peak products for peak demand periods.

Management and its engineers have long needed and sought a safe, economical method of storing products. They tried concrete tanks and other methods. During World War II when steel was scarce and the need of bomb-proof storage was evident the idea of utilizing natural structures underground was considered. It was known that certain formations had little permeability and porosity. It was determined that if a cavity could be found or developed in such a formation it might be economical to use such a cavity to store products —in particular, those of high vapor pressure, such as LPG.

Certain shales, clays, limestone, and certain sandstones, together with marble and granite, had the desired characteristics. A method of developing a closed container in any of these proved to be quite a problem. A cavity in a salt formation, however, could be washed out by circulating fresh water, which would produce brine and thereby develop a cavity to retain hydrocarbons under pressure. These early storages were developed to store LPG products, and proved to be economical.

The Author

Gaines H. Billue organized the Security Underground Company in 1951 to devote himself exclusively to underground storage problems of all types. During the last two years he has made an extensive study for the National Petroleum Council on the feasibility of underground storage for national defense, and is now engaged on underground storage problems for various oil companies.



Previous to 1947 Billue was connected with some of the major designing, engineering, and construction companies in the Southwest. In 1947 he became construction superintendent for the Sid Richardson interests handling all major construction. It was during this period he developed, promoted, and installed the first commercial underground storage well.

Intensive studies were made on the locations and characteristics of the salt formations both in the United States and foreign countries. Since the first well was completed some 46 wells with an ultimate capacity of 8,000,000 bbl are in the process of being formed or are in use. These storage wells are being used for LPG, gasoline, crude, and anhydrous ammonia.

Studies were made by and for the National Petroleum Council and revealed that storages of ½ to 1 billion bbl can be developed and located in strategic places for 25 cents per barrel.

Present prices of underground storage are as follows:

10,000 to 50,000 bbl capacity—$2.00 per barrel.

50,000 to 100,000 bbl capacity—$1.50-$1.25 per bbl.

100,000 to 500,000 bbl capacity — $1.00-.50 per bbl.

500,000 to 1,000,000 bbl capacity — .50-.25 per bbl.

Problems encountered in the installation of these projects vary from one installation to another, but they have been overcome satisfactorily. This type of storage has been firmly established to be safe, dependable, and economical with the result that the use of underground storage in the petroleum and chemical industry will continue and will be accelerated.

While underground storage was being developed in salt formations, storage in shale, sandstone, and limestone formations was not neglected. These cavities were excavated, however, by mining and some have required linings. The first one of any success was at Breckenridge, Texas, and at the present time several are being installed. The cost of these installations in comparison with those in salt formations is somewhat higher per bbl.

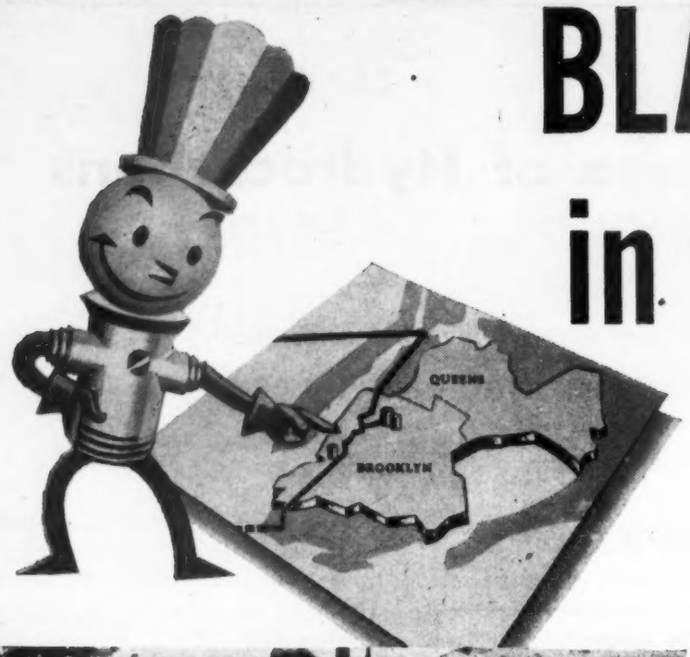
Experimental work has been carried on in the hydratable shales and points to an operation as economical as that in salt formations. A well in hydratable shale will be drilled before 1953 in order to develop a procedure and for realization of construction costs. It has been found that a cavity can be developed with less water than is required in salt formations and that the disposition of this water and cuttings from the cavity formation is much simpler. The development of underground storage in hydratable shale is highly important as there are so many suitable locations.

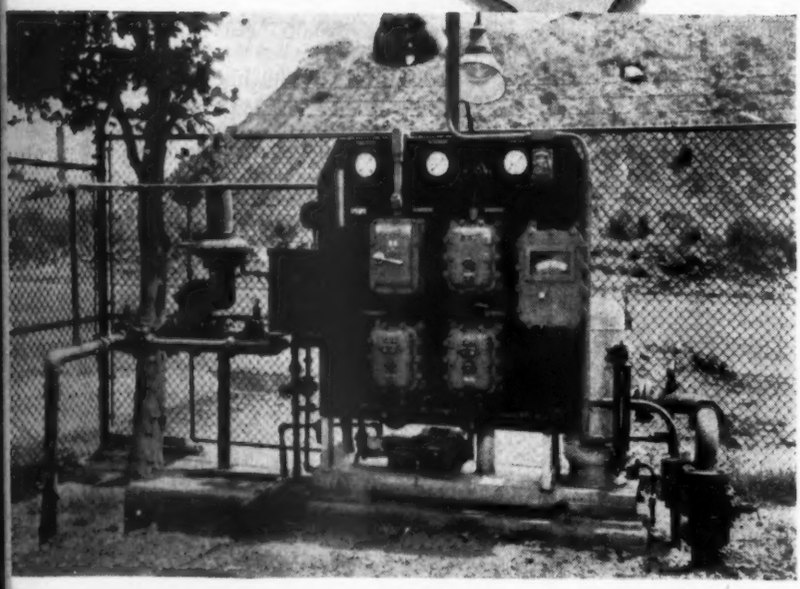
Other storage projects carried on in limestone and sand formations have required linings that will withstand the actions of hydrocarbons and the chemicals made from them. These linings have been developed and are in use. Such storage, however, until better techniques are developed, is only economical for the storage of high-vapor products, such as LPG and anhydrous ammonia. Its cost has run from $5 to $8 per bbl.

* * *

EXCLUSIVE

BLAW-KNOX Oil F in $25,000,000 G





Salient Features of
BLAW-KNOX FOGGERS

1. **Shop-assembled unit, simple to install.**
2. **Operates with minimum attention or supervision.**
3. **Temperature control is completely safe and automatic.**
4. **Electrical equipment is explosion-proof.**

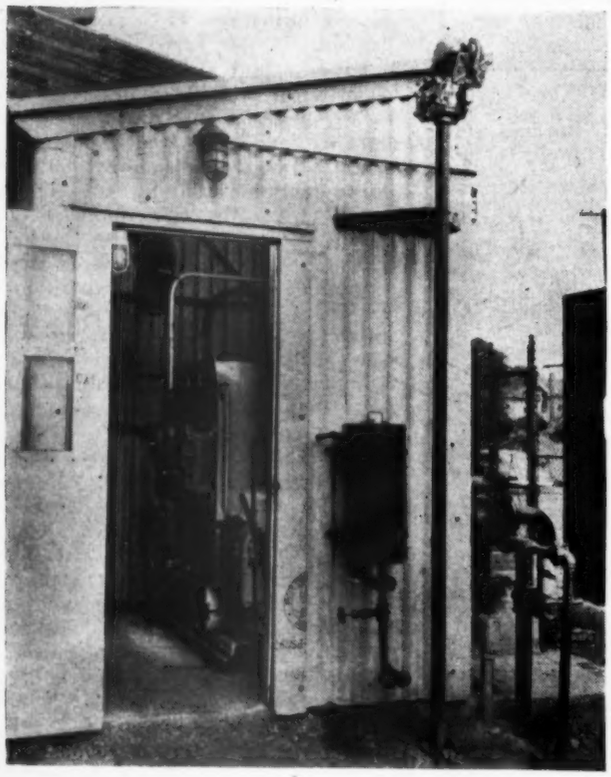
IT WILL:

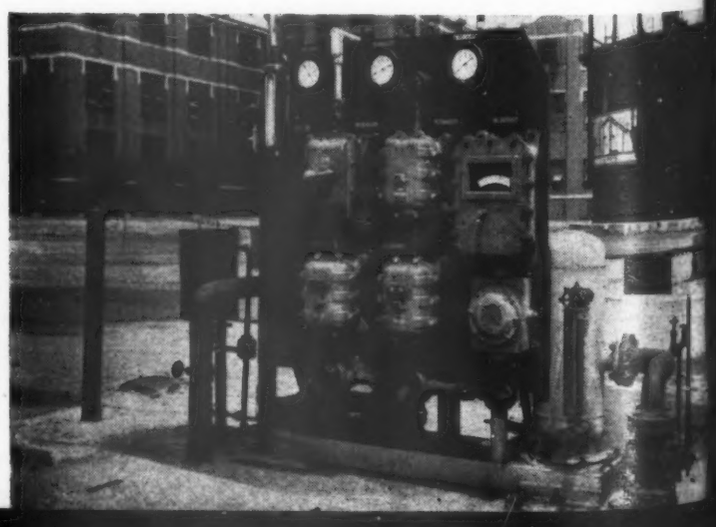
5. **Produce a stable oil fog in the gas stream.**
6. **Wet down existing dust deposits.**
7. **Moisten leather diaphragms.**
8. **Coat inside of pipe with a protective oil film.**
9. **Prevent loss of odorant from reaction with pipe scale.**

ABOVE . . . Front view of Blaw-Knox Oil Fogger at main plant, Greenpoint.

LEFT . . . Oil Fogger installed in shed at Newtown Station.

BELOW . . . Oil Fogger at main plant, Greenpoint.

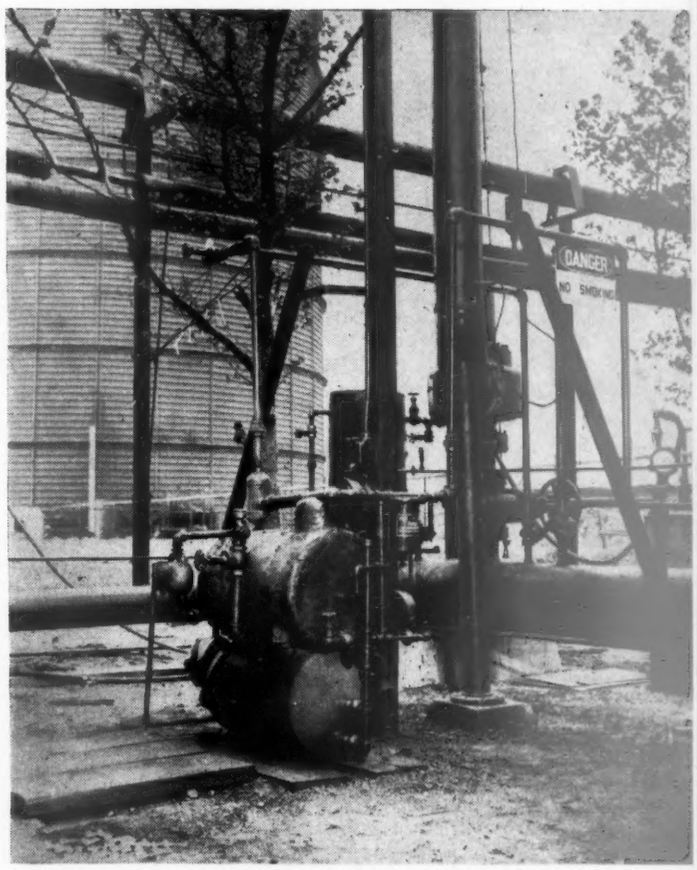




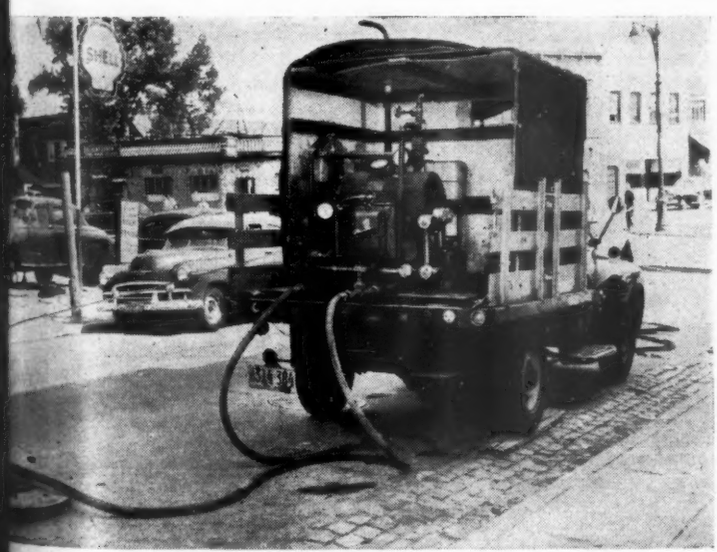
Fogger Plays Important Role Gas Conversion Job...

BROOKLYN UNION GAS COMPANY

has completed—on schedule—the stupendous task of supplying their 950,000 domestic, commercial and industrial customers with natural gas. The change-over was accomplished with a minimum of inconvenience to practically the entire population of Brooklyn and Queens. Before and during this conversion Blaw-Knox Electroil Foggers were put "on stream" at strategic points to condition both the gas and the distributing facilities . . . A report from the engineer in charge expresses his complete satisfaction with the performance of the Oil Foggers and their value to both the Company and its customers . . . For comprehensive data on Electroil and Portable types *write for Bulletin No. 2353.*



ABOVE . . . Portable Oil Fogger at accumulator station.



LEFT . . . Truck-mounted Portable Fogger in use during change-over.

Gas Equipment Department

BLAW-KNOX DIVISION OF BLAW-KNOX COMPANY

2126 FARMERS BANK BLDG., PITTSBURGH 22, PA.

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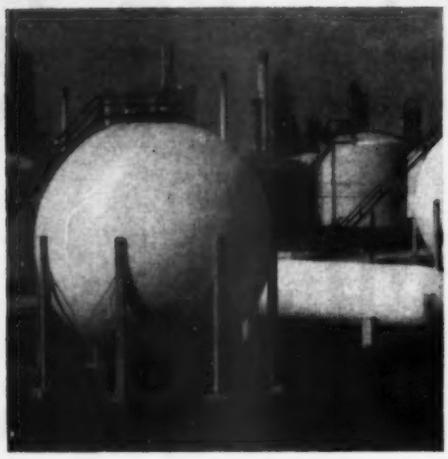
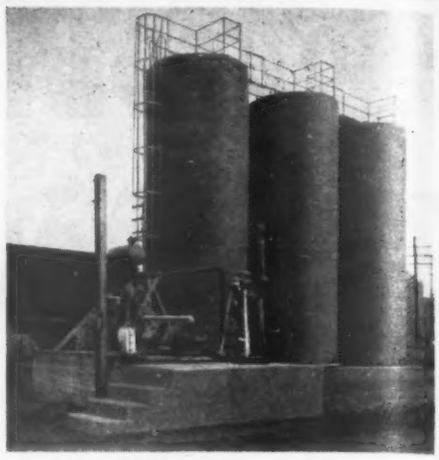


HIGH PRESSURE VESSELS

LOW PRESSURE TANKS



ATMOSPHERIC STORAGE

Tank Construction for Products Storage*

Some of the various types of tank storage described here may figure importantly in military defense considerations

L. J. COGAN

ALTHOUGH it would not be possible in this presentation to list every conceivable type of container used by the petroleum industry, the more salient units will be briefly discussed. It is believed that most of these will fall in one of three general categories:

a. High pressure storage tanks
b. Low pressure storage tanks
c. Atmospheric pressure storage tanks

As a rule, pressure storage is used for the storing of products which have vapor pressures sufficiently high to cause boiling at atmospheric pressure. Natural gasoline and liquefied petroleum gases fall within this classification, as well as some other volatile liquids such as anhydrous ammonia. Thus, a serious loss of product will occur if boiling is permitted to continue for any appreciable length of time.

The boiling temperature of a liquid can be raised simply by increasing the pressure acting upon its surface. It follows that boiling losses can be prevented by increasing the pressure just above the vapor pressure of the liquid. That is the purpose of a pressure vessel. As vaporization takes place at the liquid surface, the pressure in the vapor space increases. This in turn raises the boiling temperature of the liquid. Consequently, vaporization continues only until the vapor space pressure is equal to the vapor pressure of the stored product at its surface temperature. Vapor loss, then, is substantially reduced.

High pressure storage vessels of butt welded construction may be either shop fabricated or field erected. The Codes that usually apply are ASME or API-ASME. These requirements, as you know, provide for a factor of safety of 5 for the ASME Code and 4 for the API-ASME Code. Apropos of this, the latest 1950 ASME Code provides for a factor of safety of 4.

Shipping limitations usually dictate the maximum size of completely shop fabricated vessels. As a rule, the maximum diameter that can be completely shop fabricated and shipped is 12 ft. For some points, this can be increased to 12 ft 6 in. whereas in other areas, the maximum diameter must be kept to 11 ft. Length limitations also have been imposed by various carriers, but as a rule this is not as critical. For example, we have shipped vessels via rail which are over 100 ft in over-all length.

Field erected vessels for high pressure storage usually are either horizontal or vertical bullets or spheres. These are generally constructed in accordance with ASME or API-ASME Code.

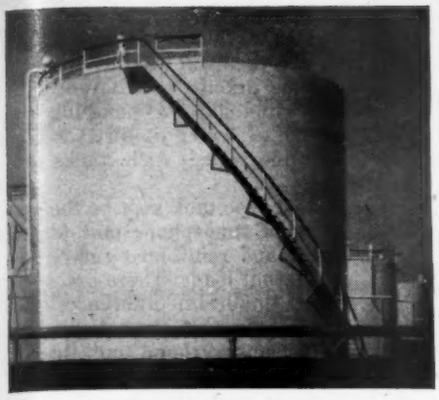
Spheres can be constructed in capacities ranging from 1500 bbl to 20,000 bbl or more and in pressures of from 30 psi to 100 psi or more. Spheres are usually selected for field erected high pressure storage, because this design offers the most practical means of obtaining nearly uniform stress throughout the shell. Therefore, plate thicknesses and erection costs can be kept to a minimum. The sphere offers one of the best methods of storing such light products as isopentane and butane.

Such recent developments as welding have tremendously increased the efficiency of high pressure storage vessels. It has been estimated that the use of welding, as compared to riveting, has reduced weight as much as 25 per cent without a sacrifice to safety. In fact, it can be safely stated that due to developments over the past ten years a welded

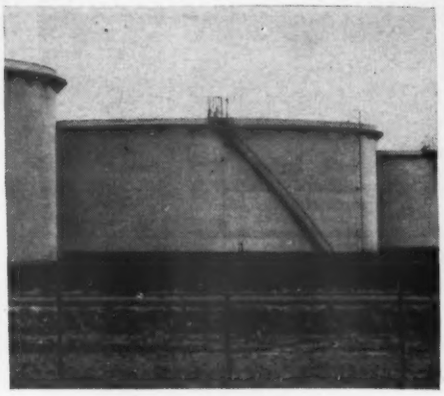
The Author

L. J. Cogan is manager of sales, Philadelphia, Pennsylvania, area, Graver Tank and Manufacturing Company, Inc. He began his career in 1935 as a welding sales engineer for the Lincoln Electric Company, shortly after graduating from Temple University. He held this position until 1943 when he enlisted in the Army. Cogan did considerable work on the design, development and construction of new Army artillery pieces, besides serving on the Army Ordnance Advisory Committee and on the Ferrous Metallurgy Advisory Committee. He joined Graver as sales engineer in 1946, shortly after his release from service. At the beginning of 1951 he became manager of sales for the Philadelphia area.

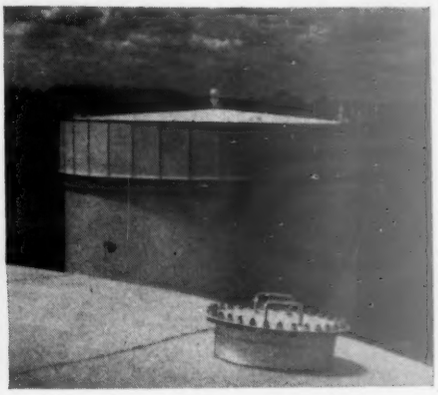
*From *The Echo*, Graver Tank and Manufacturing Company magazine.



CONE ROOF TANKS



FLOATING ROOF TANKS



EXPANSION ROOF TANKS

vessel is superior in every respect to a riveted vessel.

In general, the construction of high pressure spheres should conform to the ASME or API-ASME Code. In addition, it is suggested that column stub ends and fittings to shell plates be welded in the shop after which these components can be stress relieved. This eliminates the presence of stress raisers which might occur at these points if they are welded in the field without stress relieving.

Low pressure storage tanks, of butt welded construction, can also be either shop fabricated or field erected. The same general limitations apply regarding shipment. These tanks are generally considered for pressures of from 2½ psi to 30 psi. Construction should follow applicable codes and specifications.

The simplest and probably the most generally used of the field erected vessels of this type is a vertical cylindrical tank with a dished roof and dished bottom. These tanks are constructed in capacities of from approximately 1200 bbl to about 12,000 bbl and are usually designed for relatively low pressure.

Obviously, all of the so-called low pressure field erected tanks are difficult and expensive to construct. Their use should be limited, therefore, only for those products which cannot be stored economically in ordinary atmospheric storage tanks.

The demand for atmospheric storage tanks in the petroleum industry is very great, indeed. Practically all finished liquid petroleum products are stored in atmospheric pressure tanks. These can be both shop fabricated as well as field erected with the same general shipping limitations regarding shop built tanks applying.

In general, the shop built tanks are underwriters labeled for either underground or above ground use. The usual construction is lap welded with flat flanged heads and these tanks are fabricated in standard sizes ranging from 550 gal to 30,000 gal inclusive. The smaller sizes, that is from 550 gal to 4000 gal, are generally used underground and purchased for service stations. The larger tanks may be used either underground or above ground for small bulk storage plants.

The field erected tanks in this class, in capacities from approximately 1000 bbl to about 150,000 bbl or more, can, in general, be considered in one of the following categories:

a. Vertical cylindrical tanks with a fixed cone roof.
b. Vertical cylindrical tanks with a floating roof.
c. Vertical cylindrical tanks with a variable volume vapor space, called the expansion roof tank.
d. Large underground storage tanks.

These tanks are considered to be special structures and the design usually conforms to the requirements specified by the API Code. The roofs and bottoms are lap welded and most fabricators butt weld the shell, although the Code does permit a lap welded shell for tanks up to sizes of about 12,000 bbl.

The simplest type of liquid storage tank in this classification is referred to as a cone roof tank. It consists of a flat steel bottom resting directly on an earth grade or foundation, a vertical cylindrical steel shell and a fixed cone roof supported on roof trusses or upon a system of rafters, girders and columns. In recent years, the use of riveted construction has been replaced by welded construction because the latter provided more economical erection costs and assured a tight leak-proof joint.

A conventional tank with fixed cone roof is not capable of withstanding any appreciable amount of pressure or vacuum. Consequently, the roof must be equipped with either open vents or safety relief vents designed to operate at very low values, usually ½ oz pressure and ½ oz vacuum.

Cone roof tanks are generally used for the storage of products which have relatively low vapor pressure. These products include kerosine, fuel oil, diesel oil, and other similar liquids.

Cone roof tanks in sizes of 5000 bbl and larger are not recommended for the storage of highly volatile products such as gasoline because of the large attendant evaporation losses.

A floating roof tank is a specially designed tank and one of the most popular for the storage of motor fuels as well as sour crude oils. It consists of a flat steel bottom resting directly on a prepared foundation, usually a concrete ring or slab, a vertical cylindrical steel shell stiffened at the top by means of a suitable wind girder and a roof which floats on the liquid and rises and falls as the tank is filled or emptied.

The roof proper can be either a center weighted pan—which is a late development for the storage of sour crude—a peripheral pontoon with a flexible center deck plate, or a continuous pontoon over the entire surface which in effect is a double deck roof.

The space between the rim of the roof and the tank shell is closed off by a special sealing device to reduce evaporation loss around the tank periphery.

The main economic feature of the floating roof tank is the fact that it eliminates all filling loss, but is susceptible to some standing loss wherein vapor is lost primarily by the action of the wind which tends to take vapors out of the narrow space between the seal and the tank shell. Therefore, from strictly an economic standpoint, a floating roof tank can be used to advantage when throughput is high and tank turnovers are rapid, as might be experienced in a refinery.

Another use for floating roof tanks is for the storage of sour crude oil or distillates. Since the underside of the roof is in direct contact with the liquid, oxygen from the air is eliminated, thereby greatly decelerating the rate of corrosion which might be experienced with a cone roof tank for this service.

The variable volume vapor space tank is specially designed for the storage of volatile products such as gasoline. The most popular of this type and the one most widely used is called the expansion roof tank or the lifter roof tank. It consists of a flat bottom resting directly on a prepared foundation, usually a concrete ring or slab, a vertical cylindrical steel shell and a variable volume roof which is designed to rise or descend as the vapor and liquid expands or contracts due to temperature variations. This type tank operates on the theory of a common gas holder and provides for vapor storage as well as its own petroleum storage.

The design of most of these tanks provides for a liquid seal and the one most generally used incorporates a stabilizing mechanism whose function is to permit a smooth up and down motion even under conditions of uneven loads, such as might be experienced by drifting snow. The roof is coned to permit easy water run-off and a protective weather hood is provided to keep foreign substances

Underground tanks

from entering the launder containing the liquid seal.

The expansion roof can be operated either singly or in combination with other ordinary cone roof tanks wherein the vapor spaces of several cone roof tanks are manifolded to the vapor space of the expansion roof tank. Under these conditions, the system is actually a low pressure system operating at from 2.50 to 5.00 oz depending on the tank capacities. Sufficient capacity can be built into the expansion roof tank to accommodate the expansion of vapors of all tanks in the system, thereby completely eliminating all standing loss. Under certain operating conditions, all filling loss also can be eliminated by balancing pumping, but this is a rather rare occurence and some filling loss is usually experienced. It is evident, therefore, that the main use for an expansion roof system is for bulk storage terminals or pipe lines wherein throughput is relatively low. This is because standing loss under these conditions is much more significant than filling loss.

A rule of thumb which can be considered is the use of an expansion roof system when tank turn-overs do not exceed 12-15 times per year. It is dangerous to use such a rule, however, because there are many cases of 40 or 50 tank turn-overs wherein the economics of a particular installation recommends the use of an expansion roof system.

Under the circumstances, then, it is suggested that an economic study be made for each contemplated installation in accordance with the conditions under which the installation is expected to be operated. I might add that this procedure is being followed more and more by petroleum engineers and the results of these studies confirm the trend of the industry toward the use of floating roof tanks for refinery storage and of expansion roof systems for bulk storage as well as terminal and pipe line installations.

The various uses of shop fabricated underground tanks were previously mentioned in this presentation. There is, however, a demand for large field erected underground tanks up to capacities of 150,000 bbl or more.

The selection of large field erected underground tanks is usually dictated by either the necessity to comply with local ordinances requiring tanks to be placed underground in congested areas, or for storage for military purposes to provide concealment from invading enemy air forces.

There are no particular standards available as to size. The construction follows only a very general specification since in almost every instance the job must be engineered to suit a particular set of requirements.

Some of the variables to be considered are the available area, which in turn can affect the depth of excavation; and the overhead load requirements. In other words, will the load be merely an earth covering or must it support a road or a structure. The tank can be either round or square and either a single unit or compartmented. The shell may be straight sides and stiffened by girders or hemispherical or elipsoidal and stiffened by trusses.

The cost to construct field erected underground tanks is very high, indeed. It is estimated the cost is three to four times that of a comparable size above ground tank and this estimate does not take into account the very expensive excavation and grading costs which must of necessity be included.

In general, there are two classes of field erected underground tanks in use. The first employs a water displacement system in which each gallon of product withdrawn from the tank is replaced by an equal volume of water. This eliminates the vapor space inherent in fixed roof tanks and achieves, to some extent, the same result obtained through the use of an above ground floating roof tank.

The water displacement system is used for tanks of relatively small capacity for the storage of highly volatile products. Obviously, it is not needed for such products as diesel oil, fuel oil, or kerosine. It is doubtful whether this system would be practical for large tanks due to the difficulty of handling the large volume of water required to displace gasoline when such tanks are emptied.

The second type tank may be thought of simply as an atmospheric tank placed below grade and reinforced sufficiently to resist external loads. There are, however, several important differences. For example, temperature variations are smaller in an underground tank than in an above ground tank. Also the design of the tank is such that it will resist some internal pressure. Consequently, the underground tank has operating characteristics similar to an above ground low pressure system such as an expansion roof system. Thus, such a tank can be constructed to substantially reduce or even completely eliminate standing loss, although some filling loss will be encountered.

While these tanks are the ones most generally used for underground service, it would appear that revolutionary thinking might be indicated in regard to the future designs of underground storage containers in light of the tremendous destruction inherent in an atomic bomb explosion.

It is wondered, for example, if underground storage should not be a system of large diameter pipe, approximately 10 ft 6-in. diameter, suitably compartmented by bulkheads and spread underground over large areas.

It is believed that a design of this type would not be much, if any, more expensive to construct since the diameter of the pipe is such that components could be completely shop fabricated, which is much more economical than field fabrication. Segments could be designed to a size to permit efficient and economical handling in the field. The methods employed in the field would be similar to the laying of large diameter pipe lines which could easily be developed to a high degree of efficiency.

The advantages of such a design seem to be apparent, in that the storage facilities are dispersed over a large area and damage to a part of the system would not necessarily inactivate the complete system as may be the case if damage to a single large underground tank unit were encountered. It would seem that the disadvantage of having to obtain a site of large area could be overcome in most cases of prime targets. There is usually enough vacant ground in close enough proximity to most prime targets to meet these requirements. At least, it would appear that this suggestion or one similar to this design might merit serious consideration.

Obviously, at prime target areas, the use of above ground tanks for military purposes under existing conditions should be limited, because while I have no definite data in this regard, I can well imagine that the pressure wave of an atomic explosion would cause sufficient external pressure to cause above ground tanks to collapse, even if the explosion is some distance away. * *

Ramifications of Modern Storage

In the mid-18th century petroleum was produced in commercial quantities for the first time. But having accomplished this great feat the operator was soon confronted with the problem of insufficient surface storage.

The solution to the problem was not an easy one. Whereas, from a storage point of view, the miner had solid matter with which to contend, the petroleum producer had a viscous, volatile. and gaseous liquid. The fact that the product had the inherent characteristics of evaporation and mobility, naturally necessitated urgent measures to be taken in order to contain the hard won "black gold."

The original surface storage tanks took on the form of rugged, enlarged wooden barrels. They were, indeed, a far cry from the modern tanks that are employed now.

Today millions of gallons of crude are stored in huge non-evaporating type steel cylinders. High pressure gas is now safely enclosed in various steel spheroidal shapes. Special wooden tanks are used for highly corrosive oils, and a recent contribution is a plastic type tank.

A producer today has the identical problem of insufficient space to store his product as did his predecessor a century ago. There is an increasing demand, and to meet adequately peak requirements sufficient storage should be readily available.

In addition to surface storage, the remaining potential of a producing reservoir should not be disregarded, particularly from a national aspect. The proved reserves, or in other words the nation's "producible storage," are units of measurable wealth and strength.

During recent years considerable attention has been devoted to the feasibility of underground storage of petroleum products. Advancements have been made in this direction, and the three following methods can be adopted for storage purposes:

1. Usage of a previously productive and depleted zone.
2. Adaptation of a suitable formation. (An example is a salt dome.)
3. Conversion of cavernous or old mine workings.

A depleted portion of the Barker Dome in the San Juan Basin is being utilized as a gas storage project. The present injection pressure is 750 psi, and the rate of injection into 13 wells is 8,500,000 cu ft per day. If required the storage reservoir could in all probability produce at a maximum of 20,000,000 cu ft per day.

In salt domes a washing-out procedure has been developed for the storage of Liquid Petroleum Gas (LPG). The stored product can be withdrawn by the injection of salt water into the well. If additional storage space is required then the cavity is flushed with fresh water. There is, however, a limitation to the size of an underground store of this type. The mechanics are important considerations.

The conversion of cavernous or old mine workings for storage is based upon the control of ground water.

The selection of a suitable site for underground storage often poses difficult problems. Proximity to a market outlet may be incongruous. The formations anticipated for storage may show unsatisfactory characteristics after development. The values of permeability and porosity need close investigation, and attention to the permanent sealing qualities of neighboring formations is necessary. The economical aspect is an important factor in underground storage. The procedure is hazardous and costly.

The finding and developing of underground storage requires the cooperation of geologists, contractors, and engineers in the field of petroleum, together with civil and mining engineers.

The subject of storage is diversified. Without sufficient storage, production would be curtailed. From serious curtailment would result chaos. Storage then, has a cushioning effect in the operation of supply and demand. The whole industry is involved in the ramifications of modern storage.—J. M.

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20 Range HINGE-LOK
Casing Centralizer

PRODUCT NO. 9112

Recommended where LESS-THAN-NORMAL CLEARANCE exists between the casing ON which the centralizers are mounted and the casing THROUGH which the centralizers are run. If the formation is such as to create special problems of over-size or irregularity of the open hole, it is often advisable to run the "H-20" Centralizer on the first few joints—for ease in starting—followed by the "H-25" or the "H-50" Super-Range Centralizer.

BAKER MODEL "H"
25 Range HINGE-LOK
Casing Centralizer

PRODUCT NO. 9113

Recommended where NORMAL CLEARANCE is present, and no serious problem of over-size hole is anticipated. The "H-25" Centralizer is recommended where conditions are such that starting force would be a problem with the "H-50" Super-Range Centralizer, in which case the H-25 might be used on the first few joints and the H-50 run above it. Although the H-50 requires a larger spacing interval for easy starting than the H-20 or the H-25, fewer "H-50" Centralizers—with their superior reach—ensure even greater effective centering force.

"Reach" (Bowed Height) is vital factor

All Baker HINGE-LOK Casing Centralizers have greater reach (or bowed height) of springs in corresponding ranges than any other casing centralizers on the market.

Increased reach means adequate, all-around cementing space even though the hole size varies considerably from the drill bit size. Without this increased reach, it is quite probable that casing may contact the wall of the hole between centralizers resulting in a poor cement job at that point.

Hinged for easy mounting

Baker HINGE-LOK Casing Centralizers can be *installed in a matter of seconds* while running-in, as *no welding is required*. Just close the HINGE-LOK Centralizer *around a coupling* and then insert drive nails which *thread themselves* into the hinge knuckles, and *will not come out*. When exact spacing is desired, easily installed Stop Rings can be plug-welded at required positions.

Maximum effective centering force

Baker HINGE-LOK Casing Centralizers provide the most uniform annular cementing space around the casing. And this cementing space is present regardless of repeated flattening of the springs in a deep well, or of off-vertical condition of the hole.

The engineered bow shape of the springs, with an ideal relationship between the length and the bowed height of the springs, provides *greater landed centering force* than can be obtained from any other available hinge-type centralizer covering the same range of hole sizes.

All springs work together

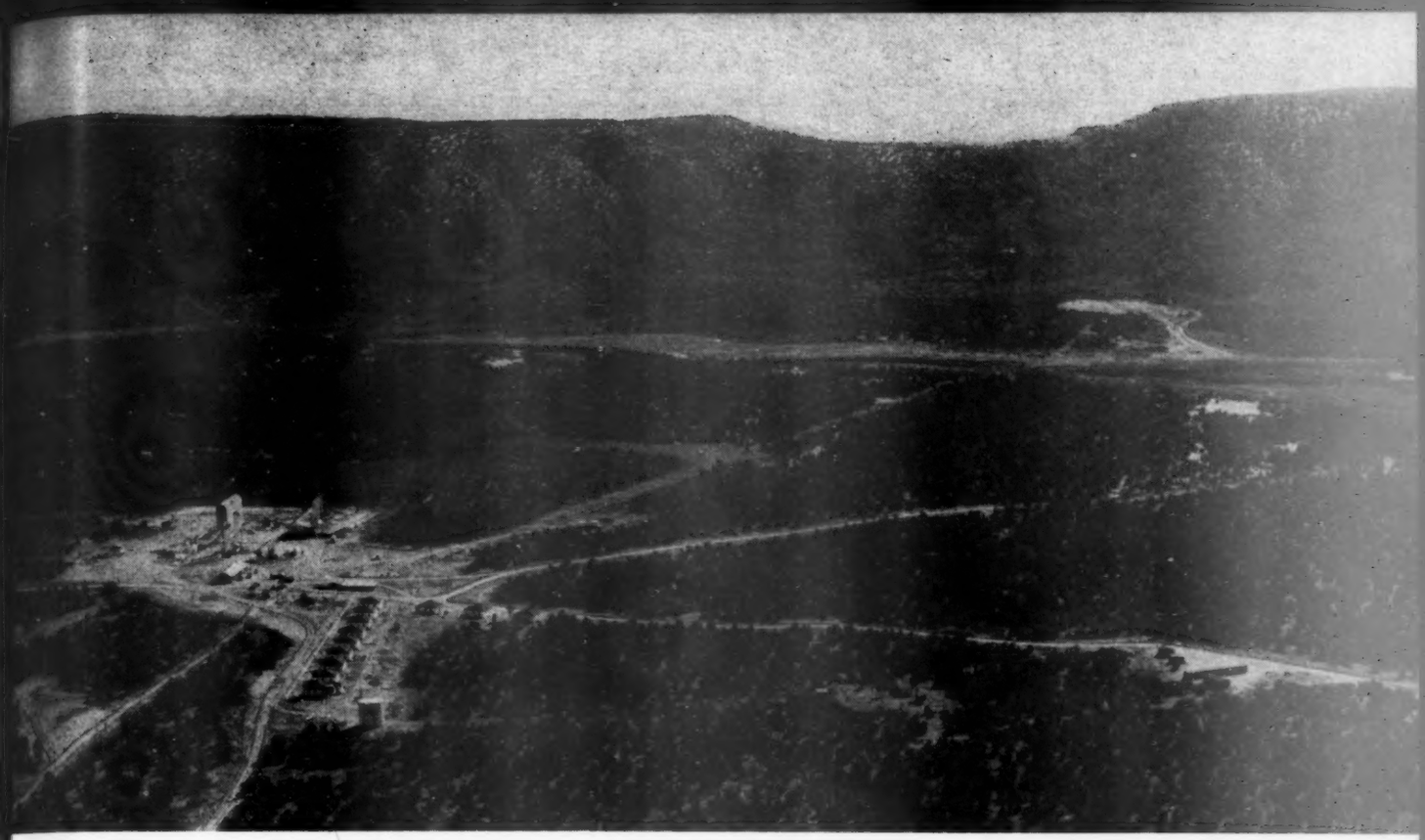
All of the powerful springs of Baker HINGE-LOK Casing Centralizers work together to offer a combined positive resistance against any tendency of the casing to contact the wall of the open hole. As the springs are forced toward the casing by contact with the wall of the hole, their effective length is decreased, thereby stiffening them and increasing their resistance to further deflection.

Unlimited rotation of casing

Whether Baker HINGE-LOK Casing Centralizers are installed around couplings or over a standard Stop Ring, the casing can be freely rotated without rotation of the centralizers.

Easy starting without snubbing

The superior spring design of Baker HINGE-LOK Casing Centralizers assures easy starting without sacrificing the powerful centering force delivered after full down-hole travel of the casing. By following the easily read "Starting Force Spacing Guide," all need for applying external starting force is eliminated even in relatively close-tolerance programs.



General view of Barker treating plant, Farmington, New Mexico.

EXCLUSIVE

P 520

Barker Dome Gas Storage Project

Petroleum is produced from a natural reservoir and is then returned to a previously depleted and underlying formation

A. M. WIEDERKEHR

"STORED GAS," as defined by the American Gas Association Reserve Committee, is "that gas which has been transferred from its original location in a gas and/or oil field to another natural underground reservoir for the primary purpose of conservation, fuller utilization of pipe line capacities, and more effective delivery to markets."

The underground storage of natural gas is no longer a rarity but Southern Union Gas Company has one of the most unusual storage projects in operation today. One of the peculiar aspects of this project lies in the fact that the project itself is situated in the San Juan Basin of New Mexico and Colorado and is only a few miles from the major gas reserves in the Pictured Cliffs and Mesaverde formations. Offhand it would seem that there could be no reason for storing gas in the vicinity of a producing gas field of this size, but Southern Union is taking gas from a lease and returning it to a storage reservoir under the same lease and this operation can be economically justified.

The Author

A. M. Wiederkehr is reservoir engineer for Southern Union Gas Company, a natural gas utility with headquarters at Dallas, Texas. Southern Union serves natural gas to 55 towns and cities in Texas, New Mexico, Colorado, and Arizona. Wiederkehr has been the company's reservoir engineer since June 1952. He also held the same position with Magnolia Petroleum Company, having been with that company five years. A graduate of Texas A&I College at Kingsville, Texas, Wiederkehr received a bachelor of science degree in chemistry and a bachelor of science degree in natural gas engineering. He is a lieutenant in the U. S. Naval Reserve, with three years of Naval duty during World War II.

Location and Geology

The Barker Dome Storage project is situated in Township 32 North, Range 14 West, of New Mexico and Colorado and lies about 20 miles northwest of Farmington, New Mexico.

The structure at Barker is a minor uplift on the west rim of the San Juan Basin. It is an asymmetrical dome with a relatively steep southeast face and a gently sloping northwest flank. The Barker Dome anticlinal axis extends in a northeasterly course to a point not far from the Colorado line where it assumes a nearly northerly direction. From the crest of this dome its axis plunges southwestward at the rate of about 100 ft to the mile, and toward the northeast its descends even more gently. The structural axis extends a total distance of about 10 miles, and maximum vertical closure is about 325 ft. There are evidences of minor faulting at Barker Dome, but none of these faults seem to have affected the continuity of the underlying gas sands.

Barker Dome field has two producing

horizons; namely the Dakota formation, producing sweet gas from about 2500 ft, and the Pennsylvanian Paradox, producing sour gas from about 9000 ft. The Dakota zone, which is being used as the storage reservoir, covers some 5000 acres and has a gross maximum thickness of about 250 ft and a net thickness of some 100 ft. The upper 60 ft is hard and tight, having a porosity of about 11 per cent and a permeability of some 2 and 3 md. The lower, more porous, section is about 40 ft thick with a porosity of some 19 per cent and a permeability ranging from 50 to 150 md. The outer limits of production are defined in the lower zone by the gas-water contact and in the upper zone by the permeability of the reservoir.

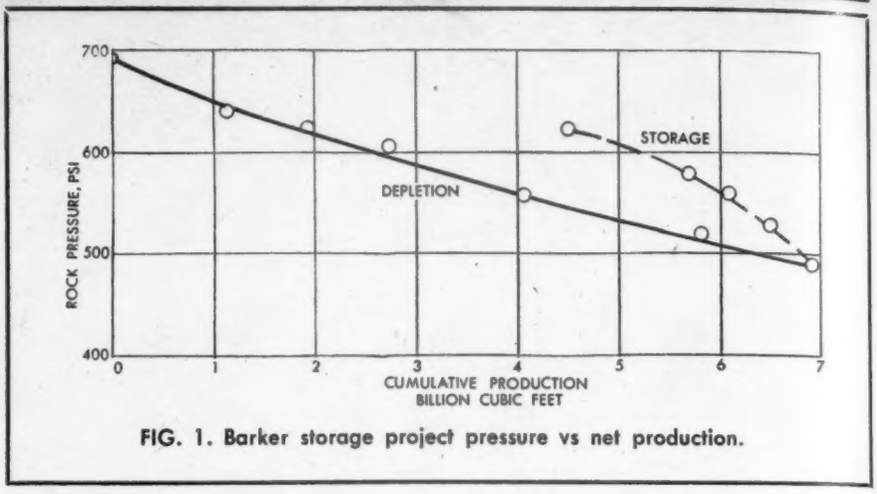


FIG. 1. Barker storage project pressure vs net production.

History

Commercial gas production was discovered in the Dakota formation by Gypsy Oil Company's No. 1 Ute in 1925. This well had a rock pressure of some 700 lb and tested 10,000,000 cu ft per day, but there was no market for this gas and the well was plugged and abandoned. In 1941 Southern Union Gas Company leased some 5000 acres in the Barker Dome area and in 1942 completed its Ute No. 1 for 7,650,000 cu ft per day. Subsequent drilling proved the Dakota zone to be of commercial importance and a pipe line was laid to the field. By 1945 eight wells had been drilled to the Dakota zone, and seven were productive of gas with open flows of from 3000 to 11,000,000 cu ft per day. In 1945 Southern Union drilled Ute No. 9 to a total depth of 9466 ft into Cambrian quartzite and discovered gas in the Paradox formation, Pennsylvanian in age. Development following this discovery proved the Paradox to be a major non-associated gas-bearing horizon, but the raw gas contained about 15 per cent H_2S and CO_2 and required purification before it could be marketed. In 1946 a purification plant capable of handling some 20,000,000 cu ft* of sour gas per day was constructed at Barker Dome to process the sour gas from the Pennsylvanian Paradox formation. The plant was kept loaded during the winter months when the demand for gas was high, but during the summer, all of its capacity could not be utilized due to the decreased market demands. The idea of storing a portion of the gas, from the outlet of the purification plant, in the Dakota formation was primarily due to the necessity of keeping the purification plant loaded, at the same time this storage gas would be available during times of peak demands. Southern Union Gas Company is a pipe line company and supplies gas produced in the San Juan Basin to both domestic and industrial consumers in Durango, Colorado; Albuquerque, Santa Fe, the Atomic Energy Commission plant at Los Alamos, as well as many small towns in this area of New Mexico. During an extreme cold spell, the hourly peak demand for gas can rise so rapidly that a source of unprorated gas from a field of high deliverability is invaluable.

*Additions to the plant, since establishment of the storage project, have been made and it is presently capable of processing 37,000,000 cu ft of sour gas per day.

In the San Juan Basin the problem of supplying a peak demand can be met by drilling additional wells, which will be produced in time of extreme demands, but these wells will not be needed for more than six months each year. Here again one of the peculiarities of the San Juan Basin enters into the economics since wells capable of producing gas into a 400-lb line cost about $80,000 to drill, plus an additional expenditure of $5000 to be connected to the pipe line. These wells upon completion will be able to deliver only an average of about 500,000 cu ft per day, which means that it would take some 30 wells at a total cost of $2,550,000 to deilver an additional 15,000,000 cu ft of gas per day.

Barker plant nearing end of construction; well in foreground is Southern Union's Ute No. 9.

Reserves

The original rock pressure at Barker Dome Dakota field was 693 lb, and periodic pressure surveys were taken during the summer months, when the demand was low, from the time of initial production in 1942 until the reservoir was converted to storage in 1947. During this interval, the pressure declined to 492 lb with a total production of 6897 million cubic feet of gas. Taking only the pressure drop and the cumulative production, the original reserves were calculated to be 23,777 million cubic feet, leaving a cushion in the reservoir of 16,880 million. No volumetric calculations could be made to check this figure since only one well was cored and only a few feet of sand analyzed.

Fig. 1 shows the pressure decline curve drawn for the period of depletion and indicates the possibility of an active water drive. The producing characteristics of the wells also gave indications of a water drive as some of the edge wells began producing noticeable amounts of water during the last year or so of production. As an active water drive was apparent in the reservoir, it

was estimated that the cushion, prior to injection, was approximately 13,000 million cubic feet rather than the 16,880 million cubic feet calculated from the pressure decline curve.

Because the company controlled the entire field, neither an accurate estimate of the reserves nor purchase of any of the gas in place was necessary at the time the reservoir was converted to storage. The factors of major importance were the rock pressure and the amount of gas that had previously been produced in order that the injection pressures and the amount of storage space at various rock pressures could be determined.

To date, we think we have had no appreciable loss of gas from our storage reservoir, but at the same time we have no means of accurately checking for such a loss. The normal method of determining a possible gas loss, the pressure volume relationship, cannot be employed in this project due to the presence of an active water drive.

The original rock pressure was about 700 lb, and we do not plan to build the stabilized reservoir pressure back to more than 650 lb; so the only loss which we could expect would be due to a casing leak. The storage gas is non-corrosive, and no trouble is anticipated with the storage wells. We are at present, however, checking pressures on the bradenheads of all sour gas wells in order to detect any casing trouble that at present would feed sour gas into the storage zone.

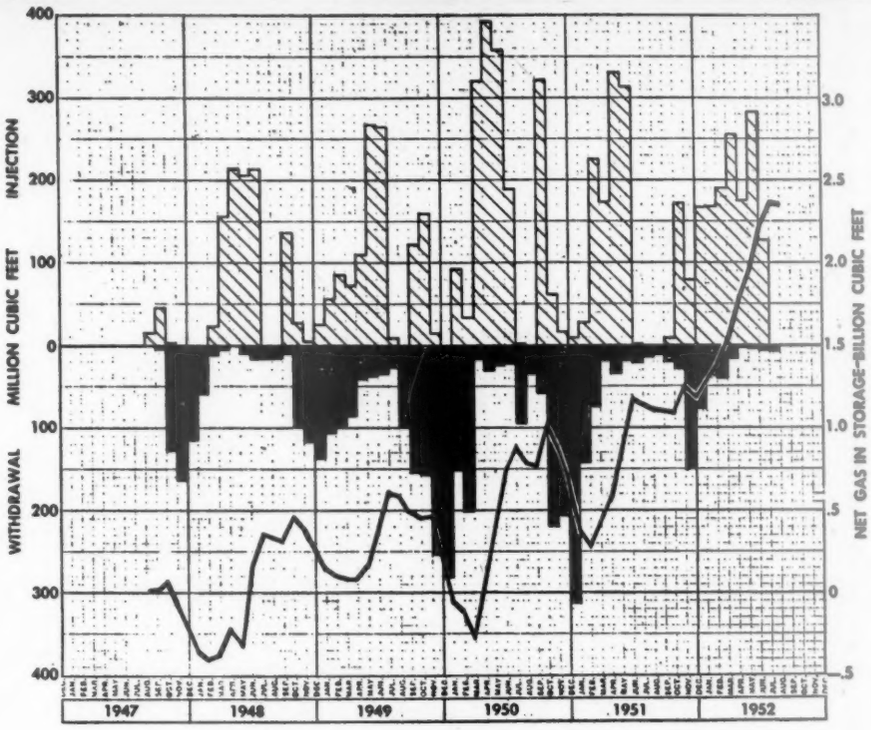


FIG. 2. Barker storage project — injection, withdrawals, and net gas in storage.

Wells and Deliverabilities

In July 1942, Southern Union Gas Company, having two productive gas wells at Barker Dome, laid a pipe line to the area and began taking gas. These two original wells were capable of delivering about 6,000,000 cu ft per day against a 375 lb line pressure. As the demand for gas increased, additional wells were drilled and in September of 1947, there were 10 Dakota wells that were capable of delivering some 9,000,000 cu ft per day. By this time, well No. 4 was non-productive due to water encroachment. The decreased deliverability per well was due to the drop in pressure, the influx of water, and the fact that several of the wells were completed in the upper low permeable sand section. In these wells the lower, more permeable, zone is below the gas water contact. Three capacity wells were drilled in 1950, and all were situated on top of the structure with little regard to spacing, since well interference is negligible due to the low permeability of the formation.

It has been found that water coming in contact with the Dakota formation appreciably decreases the productivity of the wells. For this reason, all storage wells were completed with cable tools. In the older wells the entire hole was drilled with cable tools, while in the more recent wells a rotary rig was used to drill to the top of the pay zone where casing was set and cable tools were used in the final completion.

Most of the wells have 5½-in. casing set on top of the pay and are open through the productive zone. The wells are equipped with either 1 in. or 2 in. tubing that serves only as a siphon line as gas is both injected and produced through the annular space.

TABLE 1. Completion record of Southern Union Gas Company, Barker Dome Wells.

Lease and well number	Completion date	Total depth, ft	Completion zone	Open flow MCF/day	Rock pressure, lb
Ute 1	1-30-42	2499	Dakota	7,650	698
Ute 2	5-10-42	2590	Dakota	11,000	693
Ute 3	10-11-42	2340	Dakota	8,220	658
Ute 4	9- 1-43	3345	Dakota	3,110	635
Ute 5	10-15-43	730	Abandoned	Crooked hole	
Ute 6	12-14-43	3277	Dakota	3,110	635
Ute 7	4-10-44	2377	Dakota	7,260	587
Ute 8	6-15-44	2459	Dakota	4,200	605
Ute 9	3-18-45	9466	Paradox	42,000	2975
Ute 10	12-14-44	3019	Dakota	6,000	575
Ute 11	9- 6-45	9002	Paradox	27,000	2940
Ute 12	8- 6-45	3518		Dry	
Ute 13	2-23-46	8830	Paradox	46,000	2975
Ute 14	1-13-46	2593	Dakota	3,000	530
Ute 15	12- 2-45	2325	Dakota	5,150	540
Ute 16	1-22-46	2275	Dakota	2,000	549
Ute 17	10-30-46	9387	Paradox	30,000	2700
Ute 19	3-27-49	8900	Paradox	63,000	2770
Ute 20	1- 4-50	2400	Dakota	6,000	573
Ute 21	2- 6-50	2864	Dakota	3,500	580
Ute 22	2-16-50	2341	Dakota	9,500	582

In drilling to the Paradox reservoir it is common practice to set an intermediate string of casing through the storage zone, not only to protect the zone during drilling but to prevent contamination of the stored gas from possible leakage of sour gas at later dates. As a matter of fact, this has proved its value since the casing parted in one of the deep wells, and without the intermediate string, a major portion of the stored gas might have been contaminated.

The deliverabilities of the storage wells have continually increased since injection began and the maximum withdrawal during 1951 amounted to some 13,000,000 cu ft per day. From the present pressure-volume relationship it is estimated that the storage reservoir could produce at the rate of 18 to 20,000,000 cu ft per day if necessary, but no accurate picture of the maximum deliverability is attainable as development in the San Juan Basin has made available enough gas that the project has not been required to deliver at its maximum capacity.

Acquisition of Properties

The acquisition of property was one common problem not present in the Barker Storage project, since Southern Union controlled the entire productive area of the Dakota zone prior to the time the zone was converted to storage. A portion of the productive deep pay was later assigned to other parties, but the rights to the storage zone were retained.

Located on the Ute Indian lands, the project, before establishment, required approval of the Ute Indian Council, the Department of Interior, and the United States Geological Survey. This approval was obtained after several months of

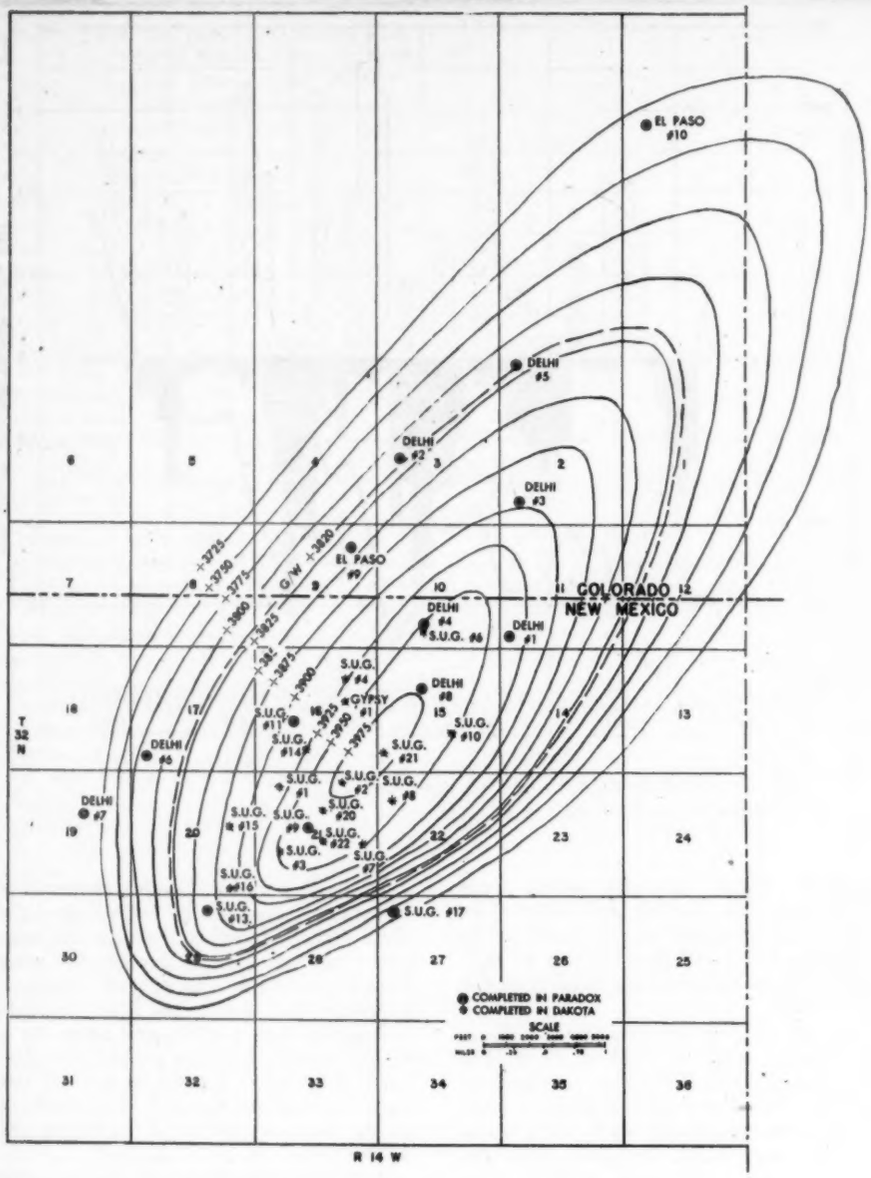


FIG. 3. Southern Union Gas Company's plat of Barker Dome Field, contoured on Dakota top.

negotiating over the royalty question and was settled to the satisfaction of all parties when it was decided to store only gas produced from Ute Indian leases. This arrangement is satisfactory for the present as only gas from the deeper zone in this same field, which is produced from Ute Indian lands, is being injected in the storage zone. When this deep zone is depleted, it will be necessary to make other arrangements with the Ute Indians if the storage project is to be continued.

Field Facilities

Gas from the outlet of the purification plant contactor, which operates at about 800 lb, goes to a glycol dehydrator and from there to a header where the stream is split into gas for the pipe line and gas for storage. The pressure of the gas to be injected is reduced at this point and the gas metered. In this manner the injection pressure is shown on the meter chart and thus becomes a permanent record. There is no record of the amount of gas being injected into any particular well, but by using this system only one meter is necessary. The gas after having been metered goes to the field injection line and to all wells. None of the wells is choked and the amount of gas injected into any particular well is based on its ability to take gas.

Gas produced from the storage reservoir is gathered through the same lines used for injection and is again dehydrated and metered. This gas is produced into a 350 lb line and is not compressed until it has traveled some 35 miles, where it enters the suction of a compressor station used to compress other low pressure gas produced in the San Juan Basin.

This project has cost very little, if we neglect the cost of the three capacity wells that would have been necessary under depletion and which will still be used in the eventual depletion of this field, since they are structurally high. To date, the extra cost that would be attributed to the storage project amounts to the well overhead charges plus an extra meter run.

Field Operations

When injection into this storage project began in 1947 the injection pressure was set at 600 lb and the volume injected amounted to some 6,000,000 cu ft per day into 10 wells. As the rock pressure increased, it was necessary to increase the injection pressure. At the present time the injection pressure is up to 750 lb and the daily injection rate is 8,500,000 cu ft into 13 wells. There has been very little if any change in the capacity of the wells to take or produce gas due to the cleaning effect around the well bore, which should occur as clean dry gas is swept back and forth across the area. Unlike most storage projects, our injection gas is not compressed; so the only contaminating agent would be a little glycol from the dehydrator, and this loss has been negligible.

Fig. 2 gives the monthly injection and withdrawal volumes as well as the cumulative net gas in storage since the storage project began. To date, the amount of injected gas has been considerably higher than that taken from storage. This over injection was necessary to increase the reservoir pressure and in this manner increase the field deliverability.

From the injection portion of the curve in Fig. 1 it can be seen that the pressure has increased more rapidly than would be anticipated from the depletion curve. This must be attributed to a water drive or erroneous pressures. We believe the pressures to be correct since the storage zone is shut in for a month or so each summer in order to obtain accurate pressures, as well as to allow the plant and field facilities, of both high and low pressure wells, to be inpected for corrosion.

It is apparent that we are tending to move the encroaching water back to its original position; wells, which during the latter stages of the depletion period were producing appreciable amounts of water and had to be cleaned regularly, are now producing for long periods without cleaning. One well, which had been completely flooded out by edge water encroachment, has indicated in recent months that it will again produce. This well is presently being tested and if these tests prove the edge water to be receding, we plan to stop our policy of over injection and attempt to maintain the amount of gas in storage at about its present volume. With the present stored volume and pressure, we have the necessary deliverability, but before leveling off our production and injection volumes, we want to be sure we have stopped the water encroachment so that it will not drown out any more of our producing wells.

In summing up the Barker Storage project, its one major drawback should be mentioned, and that is its unfavorable location with respect to the market. Considering all factors, however, the project is classified as a success. It has accomplished its twofold purpose, at a very nominal cost, of providing a place to store gas produced in excess of market demands during the summer and delivering this gas in appreciable quantities for peak loads during the winter. ★

to all our friends . . . . everywhere . . .
Merry Christmas
and of course . . . .
a happy new year
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The liquid petroleum gas is stored underground and is withdrawn when required.

Underground LPG Storage

To find a suitable reservoir is one problem and to have a successful completion method is another

B. F. NEWMAN

THE usual trend of thought found in talks and articles on gas storage seems to be figures concerning the millions and hundreds of millions of gallons of gas produced, used, stored, and not stored. So now that this item has been taken care of by more qualified men it would be an awkard attempt for one to whom a million of anything is still a lot, to go into all the high figures about the storage needed to further the LPG business. The LPG industry is convinced of the urgent need for storage and more storage, so this article will be confined to the efforts made by one group of LPG dealers who did something about the shortage of storage.

During the early part of 1952 some chance reference to underground storage planted the idea in the mind of F. Morris Sneed, owner of Butane Service Company, Fairfield, Texas, that this might be the solution to his company's ever growing shortage of butane and propane gases during the winter months. Coupled with the knowledge that there was a salt dome of the nature needed for this type storage within a short distance of Fairfield this idea expanded and Sneed approached two neighboring LPG dealers upon forming a corporation for underground storage.

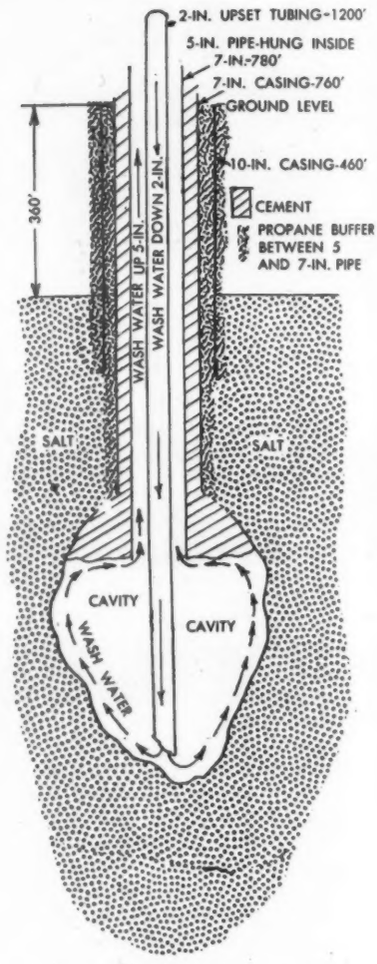
In February of 1952 Sneed, J. A. Farrar of Bellmead Butane Gas and Appliance Company, Waco, Texas, and U. C. Roney of Roney's Inc., Corsicana, Texas, formed a corporation bearing the name of Freestone Underground Storage Corporation. After gathering what information was available, which was meager indeed, actual drilling operations were begun in February on a tract of land purchased by the corporation on the Butler Salt Dome, 17 miles east of Fairfield, Texas.

Pipe was set into the salt dome without incident and washing operation was begun to enlarge a cavity in the salt for storage of LPG. For two days the washing proceeded without trouble, but on the third day lost returns occurred due to the faulty cementation. Although considerable time and effort were spent in an attempt to recement and regain circulation such was not accomplished. The well was abandoned and work was begun on the second well.

Completion Method

Considerable knowledge was gained during work on the first well, as much of what not to do as what to do. For the second well a much larger rig was employed to do the drilling. A string of 10-in. pipe was set 460 ft to insure circulation of drilling mud while drilling into the salt. Next a string of 7-in. pipe, 760 ft, was completely cemented inside the 10-in. pipe. This string of 7-in. casing was set approximately 400 ft into the salt. A string of 5-in. pipe was run to a depth of 780 ft. Total depth of hole drilled was 1200 ft and a string of 2-in. upset tubing was set on bottom.

Washing operations commenced during the height of the dry season and obtaining sufficient water to use in wash-



Schematic diagram of underground reservoir completion.

The Author

B. F. Newman is office manager of Butane Service Company and bookkeeper for the Freestone Underground Storage Corporation. He joined Butane Service in 1939 and has remained with the company since that time except for three years in Army.

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The 3¼-inch Torpedo-Jet is the most versatile charge in the Welex arsenal. Small size, deep penetration, and large diameter of hole produced, offer the oil well operator important advantages in a number of applications. The relatively small size of the tool makes it easy to run through small casing or liners for perforating in casing or liner, or shooting the open-hole section below. Also the 3¼-inch Torpedo-Jet is ideal for perforating large casing where extreme penetration is required, but when it is not considered desirable to shoot heavier charges.

Ask your Welex service engineer about this extremely useful tool. Call on Welex for prompt service day or night.

- ACCURATE SHOOTING IN SPECIFIED ZONES
- EXTREME PENETRATION
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ing operation was a major problem. The difference in the washing of the first and second wells was the use of a buffer of propane gas kept constantly under pressure in the space between the bottoms of the 7-in. and 5-in. casings of the second well. This provided a cushion of approximately 20 ft of gas, which was next to the bottom of the cement joining the 7-in. casing to the salt. By the use of this cushion when the water was pumped down the 2-in. tubing and rose up the cavity and back out the 5-in. casing, the water was prevented from coming into contact with the cement at the bottom of the 7-in. casing as the water would not mix with the gas.

The first gas was put into the well August 18, 1952. Washing was continued until the well was approximately one-half full, near the first of October. The well was filled on October 22, holding near 600,000 gal of gas.

Without the shortage of water, storage would have been completed at approximately 1,500,000 gal. Further washing will be done after the withdrawal of the gas this winter. In addition to enlarging the present well, plans call for drilling of another storage well so that both butane and propane may be stored. At this writing a 7000 gallon steel surface storage tank has been set to facilitate loading and unloading of trucks. A dehydrator will be installed before the gas is withdrawn from the well in November.

It might be pointed out that in this type operation the LPG is removed from the well by injecting salt water into the well through the 2-in. tubing and forcing the gas out the 5-in. casing. If additional storage space is required at any time then the process of washing out with fresh water can be applied.

A 15,000,000-gal salt water storage lake was constructed to hold the salt water washed from the well. This serves both as a safeguard against damage to adjoining land and to have, in the event storage capacity is reached, salt water to inject into the well to force out the gas. By injecting salt water into the well the cavity will not be enlarged.

The important factor in the completion of this storage well is that this group of dealers have actually gone a long way toward relieving their storage shortage. This will give encouragement to other dealers in that underground storage at dealer level is a definite possibility, and for the benefits reaped it is not too large an undertaking. * * *

Evaporation Loss Studied

"Evaporation Loss of Petroleum from Storage Tanks" was presented by the Group "A" Subcommittee at the API evaporation loss symposium, at the annual meeting in Chicago, Illinois, recently. It discusses the phenomenon of loss of petroleum liquids from steel tanks by "evaporation"; reviews the basic theory and mechanism of that process, and outlines scope of the practical problem of translating theory into typical data of value.

YE GOOD KING WENCESLAUS
by YE GOOD SAINT "VIC"

Sad King Wenceslaus looked out
At the royal piping,
Faulty lines lay all about
(Those leaks and breaks were griping!)
Then he saw with much delight
What was in his stocking,
He found Couplings sure leak-tight
(Victaulics famed for locking!)

"Ah! Victaulic Fittings, too,"
Roared the King now smiling,
"Elbows, Tees all grooved and true,"
(And Full-Flow in their styling!)
Good Saint "Vic" was in the know,
Vic-Groover tools were waiting,
Kingly smiles began to grow
(Their grooving's tops in rating!)

Zip! The King hooked up those sections,
Saint "Vic" did him rightly
With these very best connections
(No leaks and drips unsightly!)
For a Method that's complete
Wenceslaus is liking
Easiest way to make ends meet
(Victaulic's Four Star Piping!)

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Attention Mr. John Wamsley

My dear Sir:

Diamond chain has been a standard of transmission measure in our minds for years, and naturally we choose our new Franks "Rocket" servicing units which are factory equipped with Diamond chain.

Gulf Coast weather and corrosive conditions are severe, and the major producers keep our Franks "Rockets" busy all the time. We need a high speed, dependable chain to keep up with the fast rig-up and performance of our crew with their Franks units.

We wish to take this opportunity to express our highest respect to the engineers, workman, and inspectors of the Diamond Chain Company for producing a top quality product for the petroleum industry. You are cordially invited to visit our Franks "Rockets" on location, at any time.

Yours very truly,

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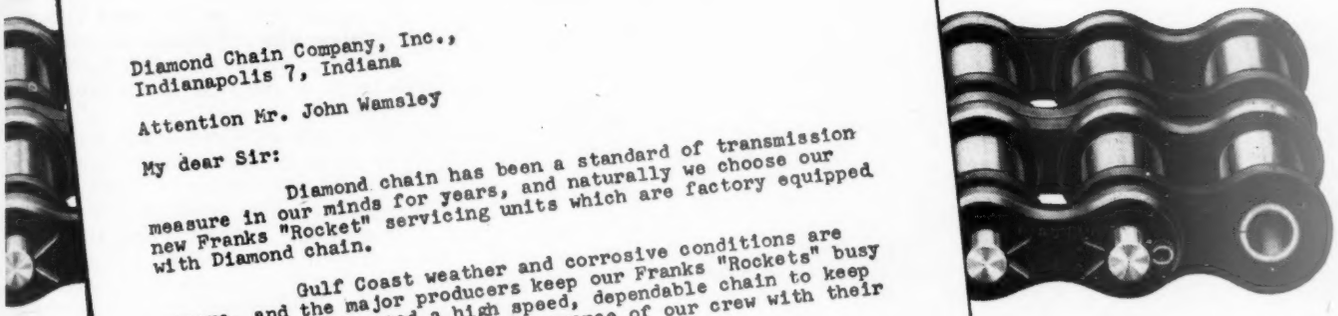

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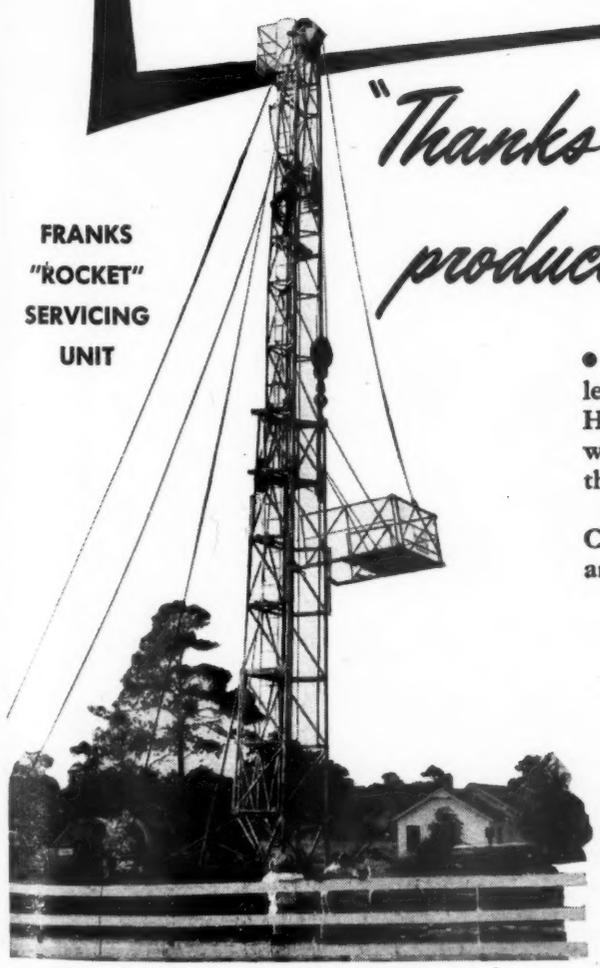

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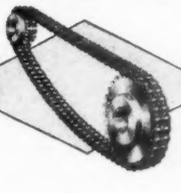

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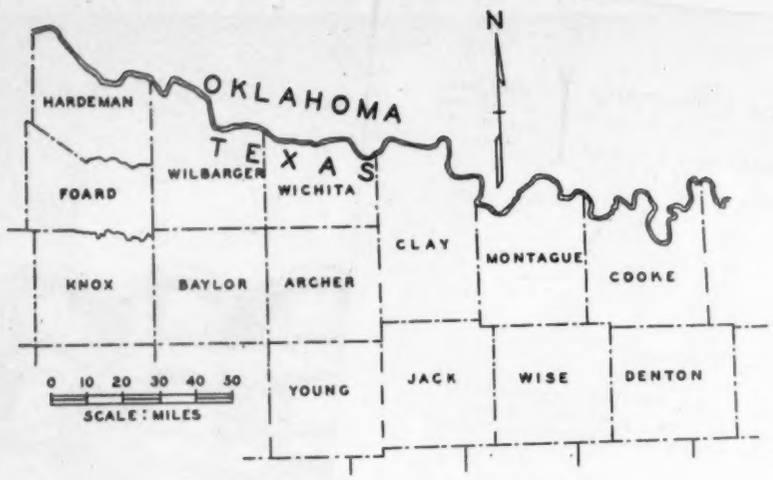

FIG. 1. Counties included in resistivity survey of subsurface waters.

North Texas

Resistivities of Water From Subsurface Formations

MARION L. AYERS*, ROLLIE P. DOBYNS*, ROBERT Q. BUSSELL*

Introduction

KNOWLEDGE of the resistivity of the formation water from an oil-productive horizon is highly desirable in interpreting electric logs. Few data of this nature have been made available to industry, however, or published in the literature. The Production Committee of the North Texas Oil and Gas Association recognized the need for more information about the resistivities of formation waters and cooperated with the Bureau of Mines in undertaking this project for study.

The area of North Texas covered in this report comprises the 14 counties in Railroad Commission of Texas District 9 (Fig. 1). The locations of the water samples that were collected are shown on maps of each county. The resistivities of the water samples collected from each county are tabulated by fields according to the six major oil-producing series or systems (Cisco, Canyon, Strawn, and Bend series of the Pennsylvanian system and the Mississippian and Ordovician systems).

The results of water analyses obtained from oil operators, oil companies, commercial service companies, and a report by Barnes[1] were used to calculate many of the resistivities. The resistivities of waters produced with oil and recovered from drill-stem tests were measured with a resistivity meter.

A study of the resistivity data showed that the formation waters in North Texas generally have very high salinities, which correspond with low resistivity

*Petroleum engineer, Bureau of Mines, Wichita Falls, Texas.

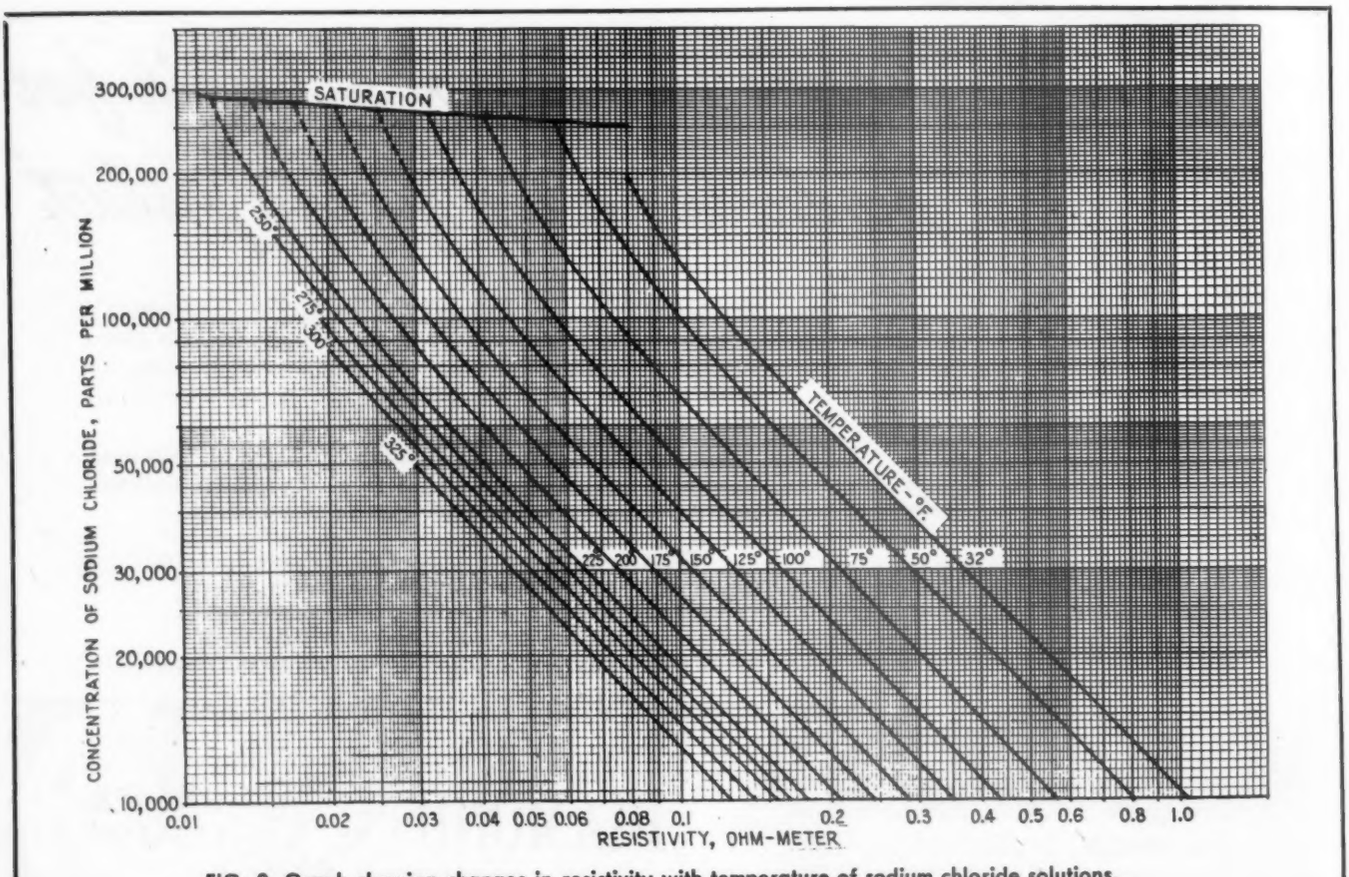

FIG. 2. Graph showing changes in resistivity with temperature of sodium chloride solutions.

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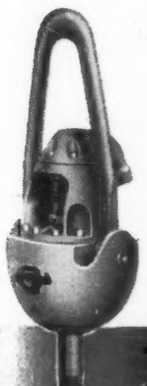

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TABLE 1. Resistivities of subsurface water samples, Archer County, Texas

Index number	Field	System or series	Average depth, feet	Av. resistivity, Rw, at 75 F, ohm-meters
1	Anarene	Cisco	1100	0.086
1	Anarene	Mississippian	5200	.065
2	Barnsdall	Cisco	1710	.057
3	Burns-Jones	Strawn	3220	.057
4	Canyon	Cisco	1800	.054
4	Canyon	Canyon	2600	.054
5	Carey	Cisco	1120	.064
6	Carpenter	Cisco	1100	.098
7	Chalk Hill	Cisco	1400	.063
7	Chalk Hill	Strawn	3690	.055
8	Conner	Mississippian	5270	.068
9	Cross	Cisco	1440	.060
10	Daume	Strawn	4100	.047
11	DeMoss	Strawn	3600	.049
12	Freeman-Hampton	Cisco	1720	.054
13	Garrett	Strawn	3780	.051
14	Gose	Cisco	1580	.061
15	Green and Flowers	Cisco	1300	.061
16	Harmel	Cisco	1420	.060
17	Holliday, East	Strawn	3800	.048
18	Hudson	Cisco	1140	.065
19	Hull-Silk-Sikes	Strawn	4300	.048
19	Hull-Silk-Sikes	Bend	4560	.048
20	Hunter Brothers	Strawn	4000	.050
20	Hunter Brothers	Mississippian	5040	.057
21	Hutchinson	Cisco	1400	.061
22	K.M.A.	Bend	4890	.051
23	Kadane	Cisco	1600	.050
23	Kadane	Strawn	4400	.044
24	John Kay	Canyon	2530	.053
25	King-Wilson	Strawn	3750	.056
26	Luke	Strawn	3890	.050
26	Luke	Bend	4880	.060
27	Macon-White	Cisco	1650	.064
28	Major	Cisco	1020	.094
29	Mankins	Cisco	1600	.056
29	Mankins	Bend	4700	.057
29	Mankins	Mississippian	5180	.054
29	Mankins	Ordovician	5250	.053
30	Megargel	Strawn	3980	.058
31	Miller and Andrews	Cisco	900	.130
32	Nichols	Cisco	1550	.061
33	North Anderson Ranch	Cisco	1350	.060
34	Peterson	Cisco	1360	.065
35	Prideaux	Cisco	700	.355

Table Continued

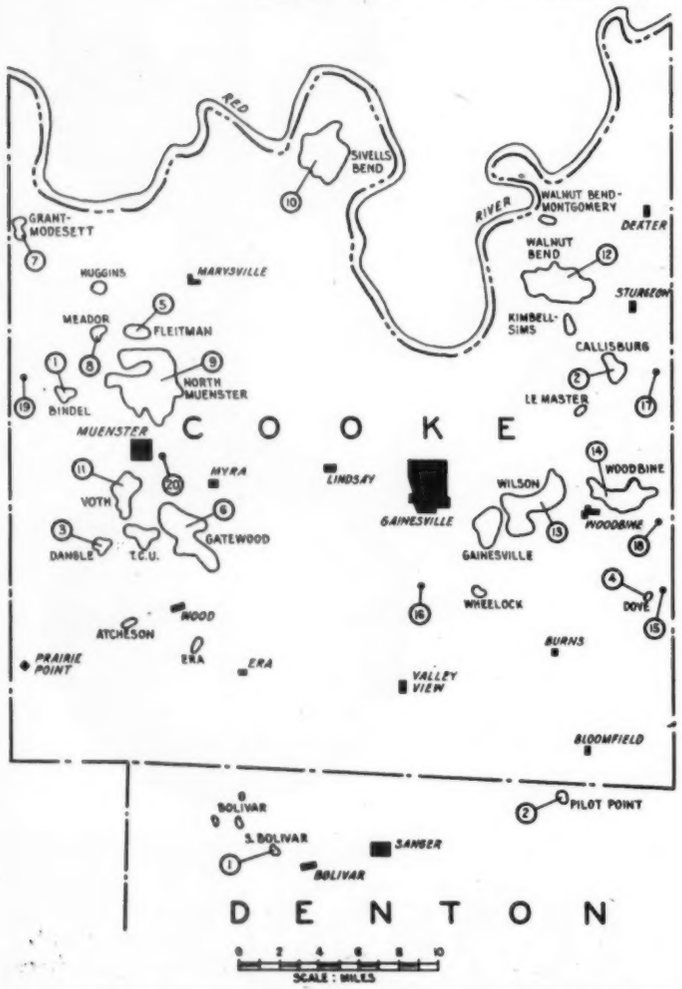

FIG. 4. Index map showing source of subsurface-water samples collected in Cooke and Denton Counties, Texas.

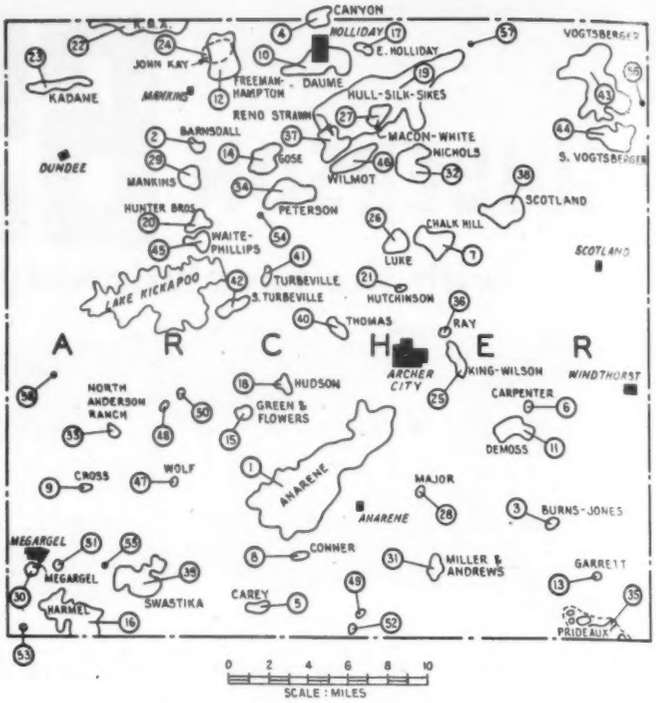

FIG. 3. Index map showing source of subsurface-water samples collected in Archer County, Texas.

Index number	Field	System or series	Average depth, feet	Av. resistivity, Rw, at 75 F, ohm-meters
35	Prideaux	Strawn	3720	.053
36	Ray	Cisco	1400	.074
37	Reno Strawn	Strawn	3960	.049
38	Scotland	Strawn	3670	.052
38	Scotland	Bend	5050	.048
38	Scotland	Mississippian	5600	.049
38	Scotland	Ordovician	5760	.049
39	Swastika	Cisco	1300	.062
40	Thomas	Cisco	1160	.065
41	Turbeville	Cisco	1490	.061
41	Turbeville	Bend	4690	.055
42	Turbeville, South	Cisco	1440	.064
43	Vogtsberger	Strawn	4810	.055
44	Vogtsberger, South	Strawn	4700	.045
45	Waite-Phillips	Cisco	1510	.060
46	Wilmot	Cisco	1580	.061
47	Wolf	Cisco	1370	.060
48	County Regular	Cisco	1370	.060
49	County Regular	Cisco	1000	.080
50	County Regular	Cisco	1380	.060
51	County Regular	Cisco	1420	.061
52	County Regular	Cisco	1000	.078
53	County Regular	Bend	4700	.050
54	Wildcat	Bend	4900	.053
55	Wildcat	Bend	4800	.049
56	Wildcat	Bend	5220	.059
57	Wildcat	Ordovician	5600	.042
58	Wildcat	Ordovician	5520	.064

TABLE 2. Resistivities of subsurface-water samples, Cooke and Denton Counties, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
	Cooke County, Texas			
1	Bindel	Strawn	1900	0.071
1	Bindel	Ordovician	3200	.047
2	Callisburg	Strawn	3250-3700	.056
2	Callisburg	Ordovician	5600	.050
3	Dangle	Ordovician	2180	.052
4	Dove	Strawn	3200	.052
5	Fleitman	Strawn	1020	.094
6	Gatewood	Strawn	1600	.065
7	Grant-Modesett	Strawn	1800	.088
8	Meador	Strawn	1680	.082
9	Muenster, North	Ordovician	1860	.061
10	Sivells Bend	Strawn	6900	.044
11	Voth	Strawn	1300	.123
11	Voth	Ordovician	1760	.065
12	Walnut Bend	Strawn	3800-5400	.054
12	Walnut Bend	Ordovician	5400-5500	.054
13	Wilson	Strawn	4000	.047
14	Woodbine	Strawn	4200	.047
15	Wildcat	Strawn	3320	.058
16	Wildcat	Strawn	1600	.113
17	Wildcat	Strawn	3600	.051
18	Wildcat	Strawn	4740	.051
19	Wildcat	Ordovician	3350	.063
20	Wildcat	Ordovician	1800	.061
	Denton County, Tex.			
1	Bolivar, South	Strawn	1600	0.083
2	Pilot Point	Strawn	1550	.076

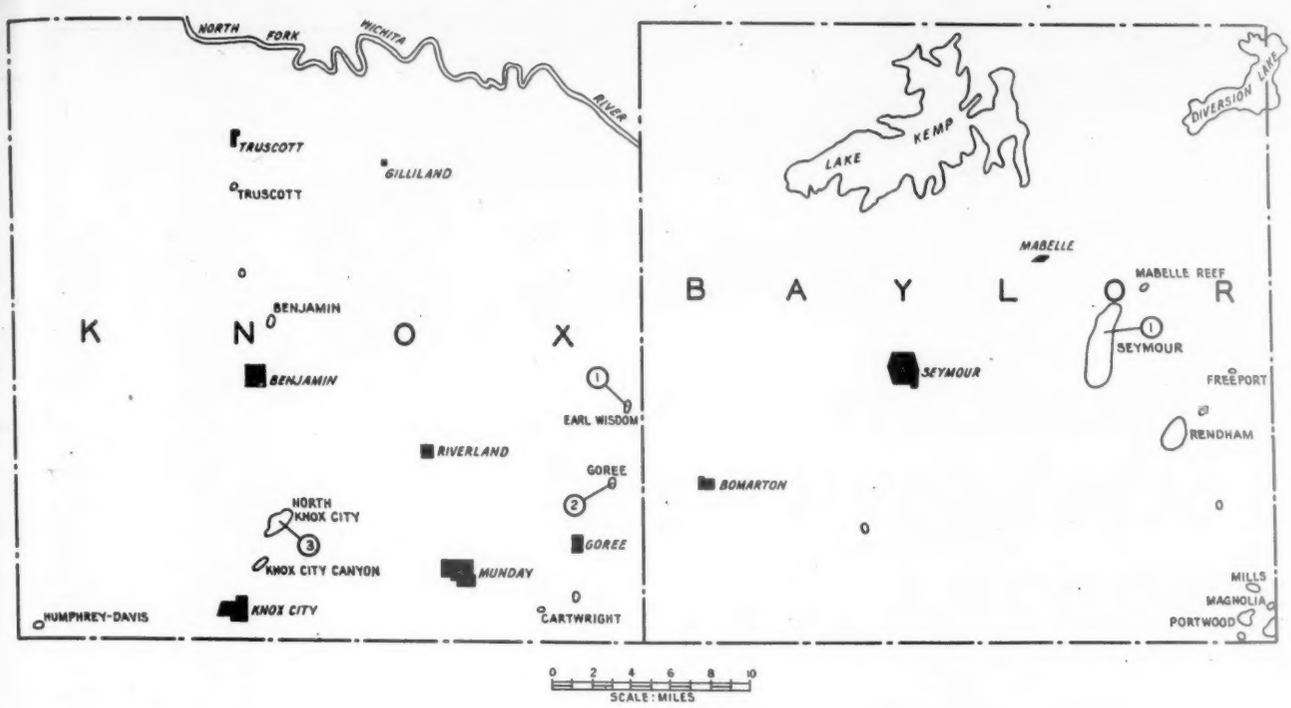

FIG. 5. Index map showing source of subsurface-water samples collected in Knox and Baylor Counties, Texas.

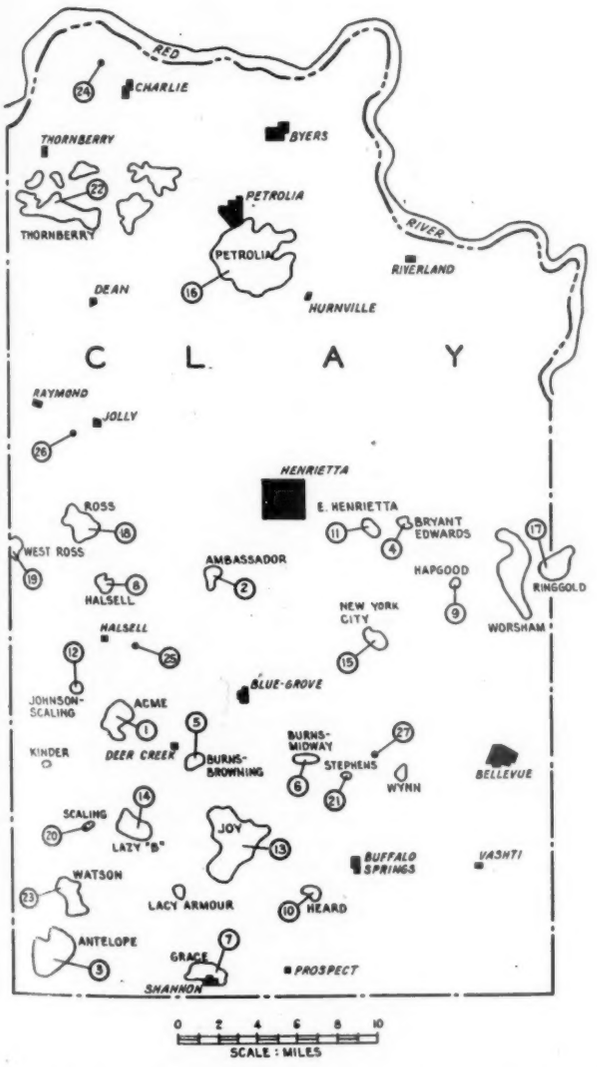

FIG. 6. Index map showing source of subsurface-water samples collected in Clay County, Texas.

TABLE 3. Resistivities of subsurface-water samples, Baylor and Knox Counties, Texas.

Index number	Field	Series	Average depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
	Knox County, Texas			
1	Earl Wisdom	Cisco	1700	0.059
2	Goree	Cisco	1620	.062
3	Knox City, North	Canyon	4170	.050
	Baylor County, Texas			
1	Seymour	Canyon	2560	0.062
1	Seymour	Strawn	4700	.048
1	Seymour	Bend	5100	.048

TABLE 4. Resistivities of subsurface-water samples, Clay County, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
1	Acme	Mississippian	5780	0.046
2	Ambassador	Mississippian	5950	.046
3	Antelope	Strawn	3200-3600	.053
3	Antelope	Mississippian	5950-6000	.048
4	Bryant Edwards	Bend	6080	.049
4	Bryant Edwards	Ordovician	6250	.045
5	Burns-Browning	Strawn	3570-3600	.061
5	Burns-Browning	Bend	5500-5650	.048
5	Burns-Browning	Mississippian	5700	.051
5	Burns-Browning	Ordovician	5800-6270	.050
6	Burns-Midway	Mississippian	6050	.047
7	Grace	Bend	5470	.050
8	Halsell	Strawn	4700	.046
9	Hapgood	Strawn	4980	.043
9	Hapgood	Mississippian	6200	.041
10	Heard	Bend	5720	.052
10	Heard	Ordovician	6500	.043
11	Henrietta, East	Ordovician	6230	.046
12	Johnson-Scaling	Ordovician	5800	.046
13	Joy	Strawn	3900-4680	.050
13	Joy	Bend	5720	.044
13	Joy	Mississippian	5950-6100	.045
14	Lazy "B"	Bend	5600	.044
14	Lazy "B"	Ordovician	6150	.045
15	New York City	Mississippian	6100-6450	.046
16	Petrolia	Cisco	1700-1780	.055
17	Ringgold	Strawn	3900-4900	.048
17	Ringgold	Bend	4900-5700	.043
17	Ringgold	Ordovician	5700	.044
18	Ross	Strawn	4700	.048
18	Ross	Bend	5360	.056
18	Ross	Ordovician	5600	.047
19	Ross, West	Strawn	4660	.048
20	Scaling	Strawn	4400	.053
21	Stephens	Mississippian	6000	.046
22	Thornberry	Cisco	1100	.051
23	Watson	Bend	5450	.046
24	Wildcat	Ordovician	3400	.046
25	Wildcat	Strawn	4840	.056
26	Wildcat	Strawn	4250	.057
27	Wildcat	Strawn	4750	.051

FIG. 7. Index map showing source of subsurface-water samples collected in Foard and Hardeman Counties, Texas.

TABLE 5. Resistivities of subsurface-water samples, Foard and Hardeman Counties, Texas.

Index number	Field	System or series	Average depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
	Foard County, Texas			
1	Canal Creek	Bend	6170	0.046
2	Johnson	Canyon	3600	.061
3	Thalia	Cisco	1470	.051
4	Wildcat	Canyon	3700	.049
5	Wildcat	Ordovician	5550	.052
	Hardeman County, Texas			
1	Wildcat	Strawn	6000	0.044
2	Wildcat (Chillicothe)	Canyon	4900	.048

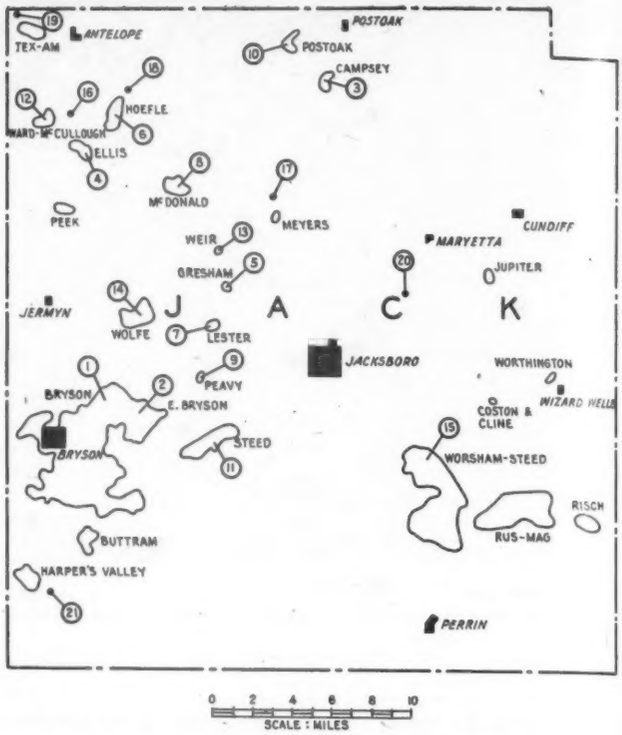

FIG. 8. Index map showing source of subsurface-water samples collected in Jack County, Texas.

TABLE 6. Resistivities of subsurface-water samples, Jack County, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
1	Bryson	Bend	4000	0.056
1	Bryson	Mississippian	5100-5200	.056
2	Bryson, East	Strawn	3100	.048
3	Campsey	Ordovician	6340	.046
4	Ellis	Cisco	690	.365
4	Ellis	Strawn	3640	.051
4	Ellis	Bend	5050	.060
5	Gresham	Ordovician	5700	.046
6	Hoefle	Bend	4900	.047
7	Lester	Mississippian	5450	.050
8	McDonald	Strawn	3580	.052
9	Peavy	Strawn	3030	.057
10	Post Oak	Ordovician	6240	.046
11	Steed	Bend	4770	.050
12	Ward-McCullough	Strawn	3620	.050
13	Weir	Strawn	2300-2460	.060
14	Wolfe	Bend	4380	.062
15	Worsham-Steed	Bend	4700	.047
16	Wildcat	Cisco	640	.380
17	Wildcat	Strawn	2440	.063
18	Wildcat	Strawn	3870	.057
19	Wildcat	Strawn	3900	.056
20	Wildcat	Bend	5150-5400	.056
21	Wildcat	Mississippian	4640	.069

values. Except in the vicinity of the Cisco outcrop and the Muenster arch, the resistivities of formation waters showed no correlation with depth.

The tabulation of formation-water-resistivity data provides a source of information that is essential in the quantitative interpretation of electric logs. The use of actual water-resistivity data eliminates its estimation and thereby increases the accuracy of electric log interpretation.

Acknowledgments

This report on resistivities of formation waters was made by the Bureau of Mines under a cooperative agreement with the North Texas Oil and Gas Association. The investigation was conducted under the general supervision of R. A. Cattell, chief, Petroleum and Natural Gas Branch, Bureau of Mines, Washington, D. C.; C. W. Seibel, director, Region VI, Bureau of Mines, Amarillo, Texas; and H. C. Fowler, chief, Fuels Technology Division, Region VI, Bureau of Mines, Bartlesville, Oklahoma; and under direct supervision of K. F. Anderson, chief, Engineering Field Studies Branch, Region VI, Bureau of Mines, Dallas, Texas.

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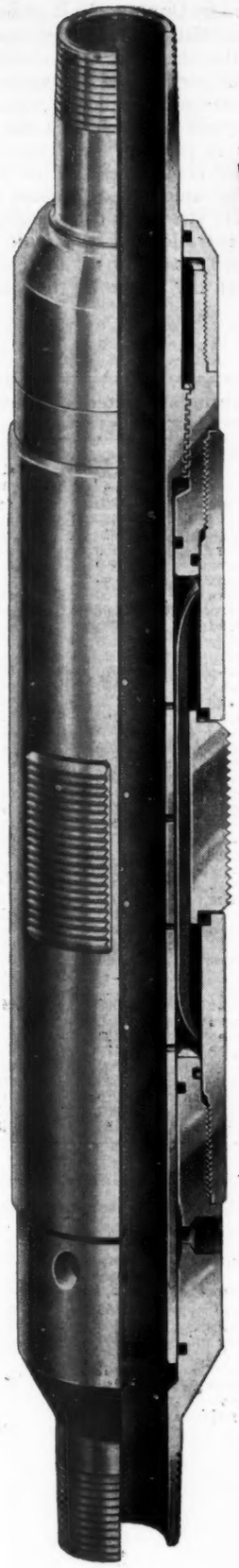

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Resistivity of Formation Water

Definition of Water Resistivity. Resistivity of water is a measure of the resistance that the water offers to the flow of an electric current. Water resistivity normally is expressed as the resistance in ohms of 1 cu meter of water to the flow of an electric current parallel to one side of the cube.

The units of water resistivity most frequently are written as ohm-meters (ohm-m) but also may be written as ohm-meters squared per meter (ohm m^2/m).

The resistivity of a brine solution decreases as the temperature increases, which is shown by the curves in Fig. 2. As all resistivity data in this report are referred to 75 F, any resistivity value to be used in electric log interpretation should be corrected to the appropriate formation temperature by using the curves in Fig. 2.

Method Used to Calculate Water Resistivities from Water Analyses. A method developed by Dunlap and Hawthorne[3] was used to calculate the water resistivities from the chemical analyses of the waters. This method of calculation is rapid and reasonably accurate, and consists principally of converting the concentrations, in parts per million, of the various ionic constituents of the water to equivalent amounts of sodium chloride (NaCl). The sum of the equivalent NaCl concentrations of the ionic constituents then may be used to read the resistivity of the water at the desired

FIG. 9. Index map showing source of subsurface-water samples collected in Montague County, Texas.

FIG. 10. Index map showing source of subsurface-water samples collected in Wichita County, Texas.

TABLE 7. Resistivities of subsurface-water samples, Montague County, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
1	Barrett	Strawn	5800	0.046
2	Belcherville	Bend	6100	.052
3	Benson	Bend	5880	.056
4	Bonita	Strawn	5400	.048
5	Bowers	Canyon	2800	.048
5	Bowers	Strawn	3000	.060
6	Bowie (Viola)	Strawn	5300	.050
6	Bowie (Viola)	Ordovician	6470-7060	.044
7	Bowie, West	Ordovician	6700	.038
8	Brooks-Wall	Strawn	5100	.049
9	Chapman-McFarlin	Bend	6000	.045
10	Childress	Strawn	2470	.051
11	Dodson	Bend	5120	.046
12	Gronow Strawn	Strawn	5830	.047
13	Hildreth	Bend	6100	.043
14	Hundley	Strawn	3420-5840	.051
14	Hundley	Bend	6200	.047
15	Illinois Bend	Strawn	3500	.050
16	Kennedy	Bend	6580	.048
17	Lewis-Stewart	Bend	6200-6350	.047
18	Miller	Bend	6300	.046
19	Minor	Bend	6260	.044
20	Mueller	Bend	6000	.048
21	Nocona	Cisco	900-1150	.055
21	Nocona	Canyon	1600	.054
21	Nocona	Strawn	*	.059
22	Queens Peak	Strawn	3900	.047
23	Richardson	Bend	6100	.052
24	Rogers and Rogers	Strawn	4150-4650	.042
25	Sanders	Bend	5970	.046
26	Spanish Fort	Canyon	1650	.051
27	Staley	Bend	6000	.046
28	Stoneburg	Bend	6150	.048
29	Willett	Strawn	3100	.051
30	Wildcat	Strawn	3680	.051
31	Wildcat	Strawn	5620	.057
32	Wildcat	Bend	6170	.048
33	Wildcat	Bend	5800	.048
34	Wildcat	Bend	5530	.056
34	Wildcat	Ordovician	6080	.048
35	Wildcat	Bend	5600	.051
36	Wildcat	Ordovician	7150	.045

* Depth not available.

TABLE 8. Resistivities of subsurface-water samples, Wichita County, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
1	Beaver Creek	Cisco	1800	0.051
2	Burkburnett	Cisco	1600	.058
3	Clara	Cisco	1700	.048
3	Clara	Canyon	2200-2500	.062
4	Clara	Cisco	1050-1800	.059
4	Clara	Ordovician	2340	.065
5	Clara	Cisco	1050	.045
6	Davidson	Ordovician	5360	.046
7	Dickinson	Cisco	1100	.066
8	Electra	Cisco	1600-1800	.049
9	Electra	Cisco	700-2200	.054
9	Electra	Canyon	2350-3150	.059
10	Electra, South	Cisco	1600-1800	.047
11	Electra, South	Cisco	1600-1800	.045
12	Electra, South	Cisco	1950	.046
13	Hammon	Canyon	2960	.053
13	Hammon	Ordovician	4700	.060
14	Hirschi	Cisco	1850	.048
15	Jones-Payne	Bend	5150	.049
16	Kempner	Strawn	3920	.047
17	K.M.A.	Cisco	2400	.053
18	K.M.A.	Cisco	1400-1800	.055
18	K.M.A.	Strawn	3900	.051
18	K.M.A.	Ordovician	4400	.046
19	Northwest	Cisco	1650	.054
20	Robinson	Cisco	1920	.046
21	Sunshine	Cisco	1200-1950	.050
22	Texhoma	Cisco	1300	.055
23	Tuttle	Mississippian	6050	.055
24	West	Strawn	4280	.042
25	County Regular	Cisco	1900	.047
26	County Regular	Cisco	1850	.057
27	County Regular	Cisco	1160	.058

temperature from the curves of NaCl concentrations versus resistivities shown in Fig. 2.

The conversion factors used in the water-resistivity calculations and an example of a calculation follow:

Ionic constituent	Concentration, p.p.m.	Conversion factor	Equivalent concentration of NaCl p.p.m.
Sodium, Na	51,570	1.00	51,570
Calcium, Ca	9,741	.95	9,254
Magnesium, Mg	2,610	2.00	5,220
Chloride, Cl	103,600	1.00	103,600
Sulfate, SO_4	980	.50	490
Bicarbonate, HCO_3	120	.27	32
Carbonate, CO_3	0	1.26	0

Total equivalent NaCl concentration = 170,166 p.p.m.
Calculated resistivity (using Fig. 2) at 75 F = 0.051 ohm-meter
Measured resistivity at 75 F = 0.056 ohm-meter
Error = —8.9 per cent
All calculated resistivity values were read from the curves in Fig. 2 at 75 F.

Direct measurement of Water Resistivity. After the resistivities were calculated for all available water analyses, samples of produced water were collected from areas not adequately covered, and resistivities of these samples were measured with a resistivity meter (Schlumberger electronic portable mud tester, type EMT-A). All measured resistivity values were adjusted to 75 F by using the curves in Fig. 2.

Application of Water Resistivity in Interpreting Electric Logs. In interpreting electric logs by Archie's[3] method, the porosity is expressed in the following form:

$$p = \sqrt[m]{\frac{1}{F}},$$

where:

p = porosity expressed as a decimal fraction;
m = cementation factor of the formation (ranges from approximately 1.3 to 2.2);
F = formation resistivity factor, which is a complex function of lithology.

However:

$$F = \frac{R_o}{R_w},$$

where:

R_o = the resistivity of a formation rock when saturated with formation water, ohm-meters at formation temperature;
R_w = formation water resistivity, ohm-meters at formation temperature.

Therefore: by substitution

$$p = \sqrt[m]{\frac{R_w}{R_o}}.$$

To illustrate a calculation for porosity from an electric log, the proper formation water resistivity (R_w) is selected from the tables for the area under investigation. In this example the resistivity is assumed to be 0.035 ohm-meter after adjusting to formation temperature. The resistivity of the formation saturated with water (R_o) is assumed to be 1.0 ohm-meter. This value can be read from an electric log at a point below the oil-water contact or measured in a laboratory. Finally, assume that the cementation factor (m) is 2.0. Normally this factor varies from 1.3 for loose sands to 2.2 for tight sandstones or limestones.

Then, by substituting these values in the porosity equation:

$$p = \sqrt[2]{\frac{0.035}{1.0}},$$

$$p = \sqrt[2]{0.035} = 0.187 \text{ or } 18.7 \text{ per cent.}$$

Another form of expressing the water resistivity in relation to electric logs is as follows:

$$SP = K \log_{10} \frac{R_m}{R_w},$$

where:

SP = magnitude of deflection of SP curve on the electric log;
K = correction factor ranging between —70 and —90 for clean sands, but as low as —50 for shaly sands and as high as —110 for limestones;
R_m = mud resistivity, ohm-meters at formation temperature;
R_w = formation-water resistivity, ohm-meters at formation temperature.

The foregoing expression may be used to determine R_w if it is not known; or, if it is known, to check the estimated value for K.

Index Maps, Resistivity Data

A simplified geologic column for the six series or systems for which water-resistivity data are tabulated is shown below.

System	Series	Typical names of producing formations
	Cisco (Virgil)	Thomas sand, Swastika sand, and Gunsight lime.
	Canyon (Missouri)	M_1 sand and Landreth lime.
Pennsylvanian	Strawn (Des Moines)	K.M.A., Vogtsberger, Hull-Silk, Bryson, and Walnut Bend sands.
	Bend (Atoka)	Atoka conglomerate, Marble Falls lime, Caddo lime, and Caddo conglomerate.
Mississippian	—	Chappel lime.
Ordovician	—	Viola lime, Simpson sand and dolomite, and Ellenburger lime.

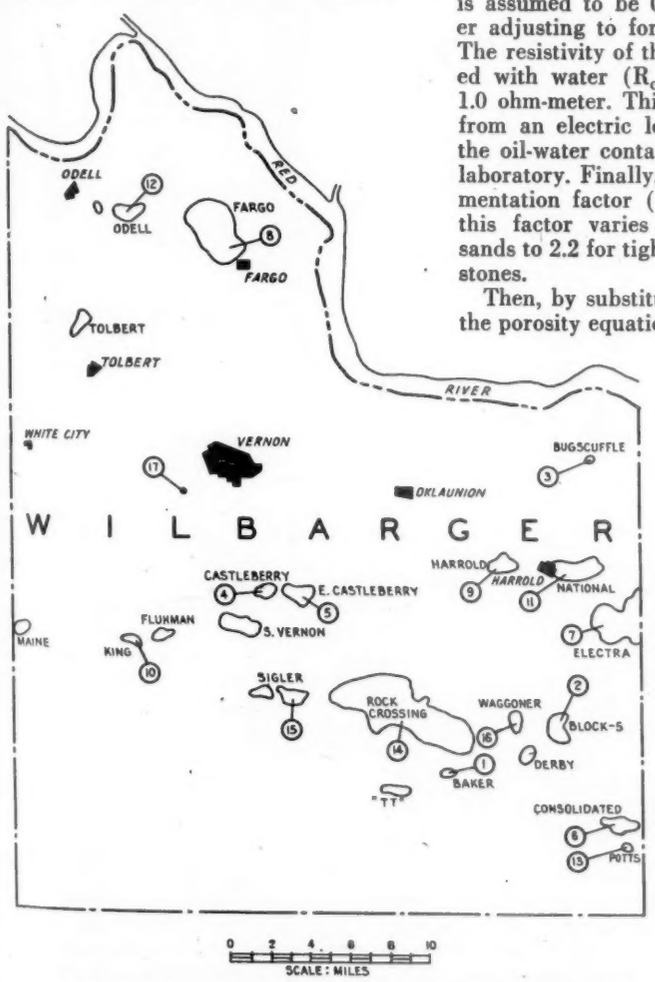

FIG. 11. Index map showing source of subsurface-water samples collected in Wilbarger County, Texas.

TABLE 9. Resistivities of subsurface-water samples, Wilbarger County, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
1	Baker	Cisco	1950	0.045
2	Block-5	Cisco	1900	.046
3	Bugscuffle	Mississippian	6000-6300	.047
4	Castleberry	Cisco	1300-3250	.046
5	Castleberry, East	Cisco	2890	.049
6	Consolidated	Cisco	1840	.046
6	Consolidated	Strawn	3750	.048
6	Consolidated	Bend	4000	.046
7	Electra	Cisco	1600-1800	.047
8	Fargo	Cisco	3300	.047
8	Fargo	Canyon	4350-4700	.046
8	Fargo	Strawn	5200	.050
8	Fargo	Ordovician	6300	.043
9	Harrold	Canyon	3200	.050
9	Harrold	Bend	4200	.047
10	King	Cisco	1460	.046
11	National	Canyon	3700	.046
11	National	Bend	4480	.045
11	National	Ordovician	4900	.044
12	Odell	Canyon	4770	.045
12	Odell	Ordovician	6450	.047
13	Potts	Ordovician	4500	.048
14	Rock Crossing	Cisco	950-2450	.046
14	Rock Crossing	Canyon	2550-3100	.048
14	Rock Crossing	Strawn	3530	.047
14	Rock Crossing	Ordovician	3800	.046
15	Sigler	Canyon	2650	.048
16	Waggoner	Bend	3650	.041
17	Wildcat	Canyon	4600-4870	.050

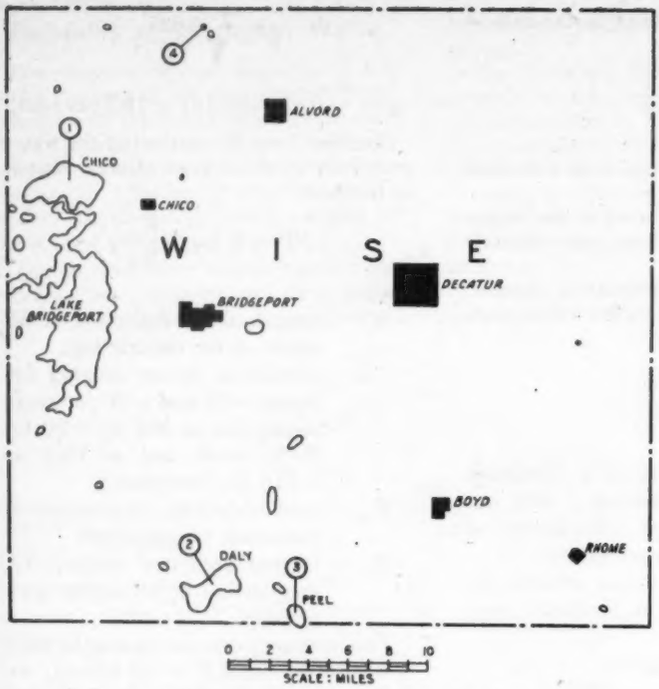

FIG. 12. Index map showing source of subsurface-water samples collected in Wise County, Texas.

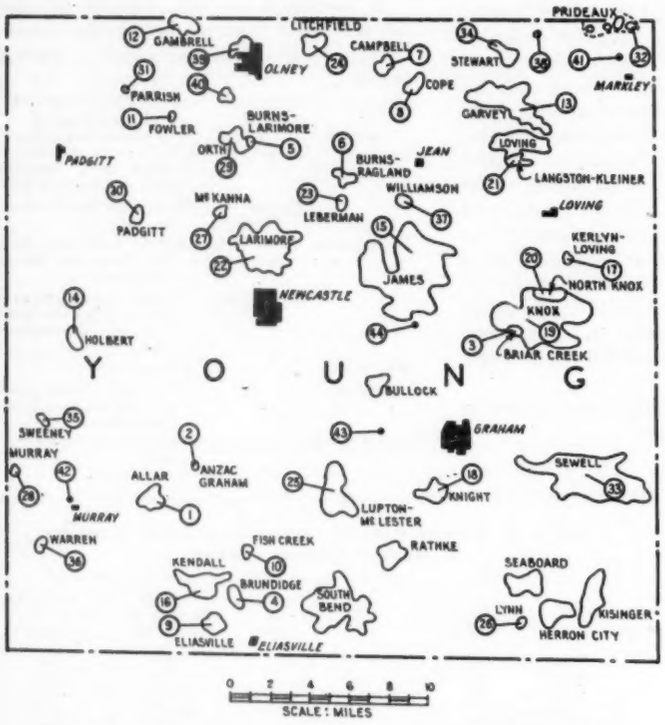

FIG. 13. Index map showing source of subsurface-water samples collected in Young County, Texas.

As the geology of North Texas is very complex and the classification of the formations difficult to define, this geologic column is a simplification of the classification most generally accepted in this area.

The index maps (Figs. 3-13) show the locations of the water samples used in this survey. The resistivity of each water sample, corresponding to the index number shown on the county map, is given in the table (tables 1-11) for that map. In addition, the tables give the name of the system or series for the formation sampled, the name of the field, and the average depth or range in depth of the formation sampled. The names of the oil fields given in the tables and shown on the maps are for identification in this report and may or may not correspond with the field names used by the Railroad Commission of Texas or by some oil companies and operators. Frequently the index numbers on the maps refer to certain oil fields, but not the exact point in the field from which the sample was obtained. For example, index Number 2, referring to the Burkburnett field in Wichita County (Fig. 10), does not mean that the water samples were obtained at the exact point shown on the map. A total of 13 water samples was obtained from all sections of the Burkburnett field, and the resistivities were averaged to give the value shown in the table. In some large fields where the differences in water resistivity were so great that an average would not be representative, more than one index number is used to locate the different areas from which water samples were obtained, and the resistivity for each area is given in the table. In the same general area or field, the same index number may refer to water samples from several different formations.

The simplified geologic column shows the system, series, and typical producing

TABLE 10. Resistivities of subsurface-water samples, Wise County, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
1	Chico	Bend	5300	0.057
2	Daly	Strawn	3300	.080
2	Daly	Bend	3550-3870	.085
3	Peel	Bend	3950	.082
4	Wildcat	Ordovician	7030-7270	.057

TABLE 11. Resistivities of subsurface-water samples, Young County, Texas.

Index number	Field	System or series	Average or range in depth, feet	Av. resistivity, Rw, at 75 F, ohm-meter
1	Allar	Strawn	2750	0.059
1	Allar	Bend	3550-4100	.055
2	Anzac Graham	Bend	4000	.074
3	Briar Creek	Strawn	2760	.054
4	Brundidge	Mississippian	4500	.061
5	Burns-Larimore	Mississippian	4920	.068
6	Burns-Ragland	Strawn	2600-3100	.057
6	Burns-Ragland	Bend	4000	.054
7	Campbell	Cisco	850	.175
8	Cope	Bend	4490-4710	.051
9	Eliasville	Strawn	1700-2370	.064
9	Eliasville	Bend	3460	.058
10	Fish Creek	Strawn	2390	.062
11	Fowler	Cisco	980	.061
12	Gambrell	Cisco	1070	.063
13	Garvey	Cisco	550	.305
13	Garvey	Strawn	3560	.050
13	Garvey	Bend	4270-4630	.048
14	Holbert	Strawn	2590	.054
14	Holbert	Bend	3860	.052
15	James	Bend	3800-4200	.053
16	Kendall	Strawn	2770	.060
16	Kendall	Bend	3470	.059
16	Kendall	Mississippian	4500	.074
17	Kerlyn-Loving	Strawn	2920-3400	.053
17	Kerlyn-Loving	Bend	4210	.061
18	Knight	Bend	3800	.048
19	Knox	Strawn	2300	.058
20	Knox, North	Bend	4100	.050
21	Langston-Kleiner	Strawn	3520	.050
22	Larimore	Cisco	650	.073
23	Leberman	Mississippian	4850	.074
24	Litchfield	Cisco	1010	.069
25	Lupton-McLester	Bend	3750-4010	.054
26	Lynn	Strawn	2500	.059
27	McKanna	Cisco	750	.065
28	Murray	Mississippian	4500	.088
29	Orth	Cisco	860	.064
30	Padgitt	Mississippian	4720-4830	.076
31	Parrish	Cisco	1050	.060
32	Prideaux	Cisco	700	.390
33	Sewell	Bend	4000	.043
33	Sewell	Mississippian	4300	.063
34	Stewart	Cisco	770	.263
35	Sweeney	Bend	3760	.051
36	Warren	Strawn	2910	.055
36	Warren	Bend	3630	.051
37	Williamson	Mississippian	4970	.063
38	County Regular	Cisco	750	.260
39	County Regular	Cisco	1000	.061
40	County Regular	Cisco	930	.060
41	Wildcat	Strawn	3670	.057
42	Wildcat	Bend	3640	.053
43	Wildcat	Bend	4000	.059
44	Farm water well	Cisco	*	9.50

* Depth not available.

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formations from which water samples were obtained; but only the system or series is shown in the tables of resistivity values. For example, water samples from the KMA, Vogtsberger, Hull-Silk, Bryson, and Walnut Bend sands are shown in the tables only as the Strawn series, because it was impracticable to obtain enough water samples from any particular formation to give good coverage of the area. In addition, in many fields, the resistivity value remained nearly constant with considerable changes in depth.

Concluding Statement

An analysis of the data obtained for this study indicated a range in resistivities from a minimum of 0.038 to a maximum of 9.50 ohm-meters at 75 F. This large range in resistivity is misleading because the high maximum values occurred near the outcrop of the Cisco series and on the uplift of the Muenster arch. If the very high resistivities of waters obtained from the Cisco series near its outcrop in Young and Jack Counties and from the Strawn series where it is very shallow on the Muenster arch in Cooke County are disregarded, the remaining resistivities would range from a minimum of 0.038 to a maximum of 0.088 ohm-meter at 75 F. This range in resistivity is very small for such a large areal extent and changes in depth.

The generally slight variation in resistivity of the water samples prevents its use for water or formation identification. By interpolation, however, the data presented here will provide reasonable values for water resistivity in an undrilled or wildcat area. In addition, these data will offer a correlation check for future resistivity data that may be obtained.

All of the resistivity data were checked by correlation for possible errors, and any values that appeared in doubt were checked for accuracy or discarded. The most questionable samples were those obtained from drill-stem tests; out of 216 water samples thus obtained, 145 were considered uncontaminated, and 71 were considered contaminated and discarded.

It should be remembered, in using these data, that the resistivity values must be adjusted to the temperature of the formation being investigated.

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3. Archie, G. E., The Electrical Resistivity Log as an Aid in Determining Some Reservoir Characteristics, Reprinted Trans. Am. Inst. Min. and Met. Eng., Petrol. Devel. and Technol., Vol. 146 and 151, 1942 and 1943, pp. 54-62.

★ ★ ★

The Authors

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Rollie P. Dobyns graduated from Texas A & M College in 1939 with a BS degree. For the next three years he was an engineer on a contract gravity crew. During the war years, he served in the Air Force and was discharged with the rank of captain. Since 1948 he has been associated with the Bureau of Mines as a petroleum engineer in the Wichita Falls, Texas, sub-office.

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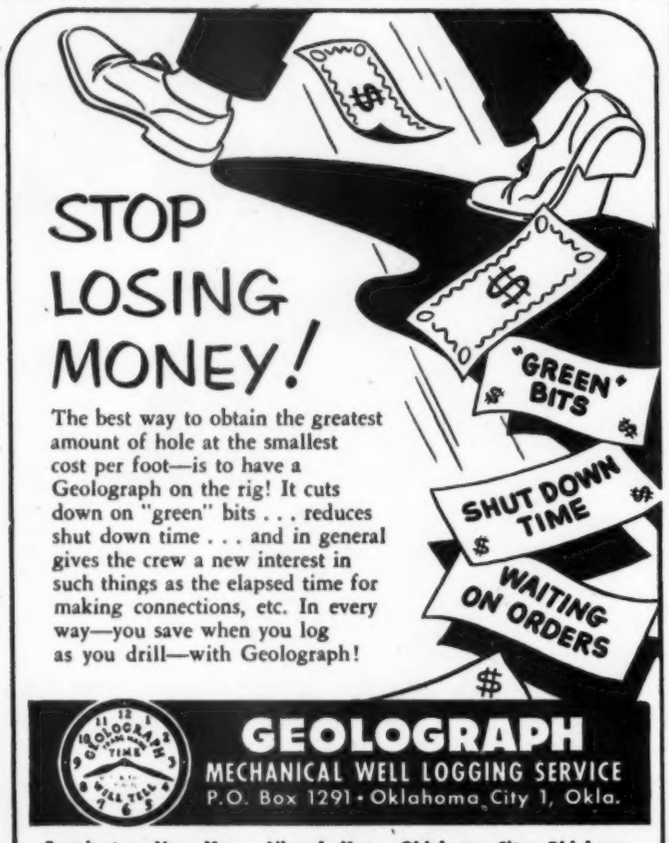

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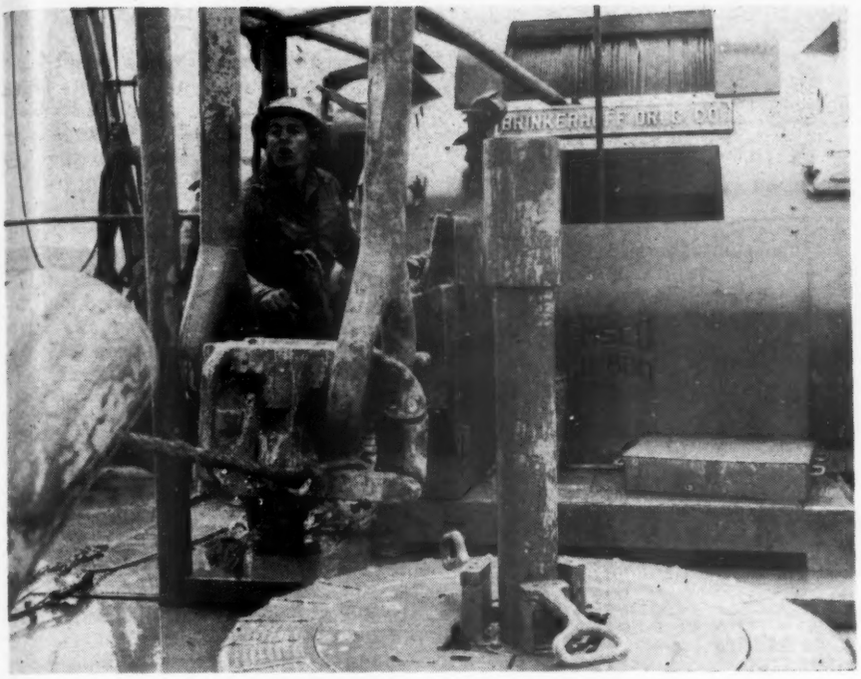


Shell Unit No. 9, Jumping Pound. Drilling through steeply dipping structures presents difficult problems. G. Berthiaume, driller for Brinkerhoff, prepares to pick up and make connection to try and break circulation.

Operating in the Jumping Pound Field

JACK MENNEER*

TODAY in the foothills of the Canadian Rockies, some 25 miles due west of Calgary, is situated Shell's Jumping Pound gas field. The possibilities of this area were first recognized several years ago by Dr. G. S. Hume when the Canadian Geological Survey was conducted under his direction. The late R. A. Brown, Sr., who discovered the light oil reserves of Turner Valley was also an early supporter of foothill petroleum accumulation possibilities.

In 1938, the Brown Consolidated No. 1, R. A. Brown lease, was drilled but was unsuccessful. Two years later, the Shell Oil Company of Canada, Limited, became active in the area and in 1941, when negotiations with R. A. Brown were completed, an intensive seismic survey was undertaken. After two years of laborious field studies, the first well was drilled in Jumping Pound, and although commercial production was not obtained, sufficient geological data were available to support the theory that the accumulation was to the east. In line with this, additional seismic work was done and in 1944, the discovery well was drilled. Gas and some distillate were produced from the Madison limestone, which is also Turner Valley's producing formation. Drilling was curtailed from 1947 to 1950 due to the lack of a gas market, but in June 1950, an agreement was signed between Canadian Western Natural Gas Company and Shell Oil Company of Canada, Limited, to provide gas for southern Alberta.

The Jumping Pound structure is an elongated overthrust about 10,000 ft deep, and has proved reserves covering an area of 5 miles long and 1 mile wide. The axis of the field is NNW by SSE. Five gas wells are currently producing and two more wells are being drilled.

Drilling

Overlying the productive limestone are steeply dipping beds, the maximum dip being as high as 75. Penetration of these beds presents a serious drilling problem as the hole rapidly deviates from the vertical. In view of the limited breadth of the structure, the course of the borehole must be closely controlled and rapid progress is therefore difficult. A constant watch must be kept on the directional behavior of the hole. This does not imply that in normal drilling the deviation can be neglected, but in this area, known as the "crooked hole country" or "foothill drilling," the problem of avoiding deviations is accentuated.

The drilling policy calls for deviations of 1 deg at 1000 ft, 2 deg at 2000 ft, and 3 deg maximum below 2000 ft. The maximum of 3 deg is the ideal, but to date it has been impossible to remain within this maximum; however, 6 deg has been the highest deviation. The general average rate of penetration is 30 ft per day and it has been found by experience that a rotary table speed of 200 rpm, and 2000 lb of weight, and a roller type bit give the most satisfactory results.

A normal clay base mud with 6 per cent diesel oil is used for drilling down to 1000 ft and at this depth, either 13⅜ in. or 10¾-in. casing is set. A 16 per cent oil emulsion mud (diesel oil and Jel Oil E[1]) is used in drilling down to the top of the pay, which is at an average depth of 9600 ft. Prior to using this type of mud, much trouble was experienced with heaving shales, and washouts and the application of an oil emulsion mud has overcome these tendencies. The generalized mud characteristics are: weight 10 lb per gallon, viscosity 100 sec (Marsh funnel), water loss 4 ccs down to the top of the pay, and 2 ccs when penetrating the pay, and a pH of 9.5 to 10.

Seven-inch casing is cemented on top of the pay and it has been found that a good cement bond is obtained when the technique of reciprocating the casing has been applied. This necessitates the use of wall scratchers spread throughout the interval to be cemented, and casing centralizers placed at certain points along the casing. Prior to cementing, the casing is reciprocated for an hour over a length equivalent to the

[1]A Shell product.

*Editor Drilling and Producing.

EXCLUSIVE

Shell Oil Company of Canada has been actively engaged in the Foothill production in the precarious formations of the Canadian Rockies for 14 yr.

In the Jumping Pound field in Alberta, drilling through steeply dipping structures of up to 75 deg presents a difficult problem and requires all the know-how that can be mustered. Rates of penetration must be slow by design. Well costs are high — in excess of $400,000 for a 10,000-ft well plus cost of essential surface equipment.

Sub-zero weather creates severe production problems and hot oil is circulated in the well in order to sustain gas production.

To obtain production from one of the worst crooked hole areas in the world, especially in view of climatic conditions, is no mean achievement. The accomplishment and maintenance of large volume gas production are discussed.

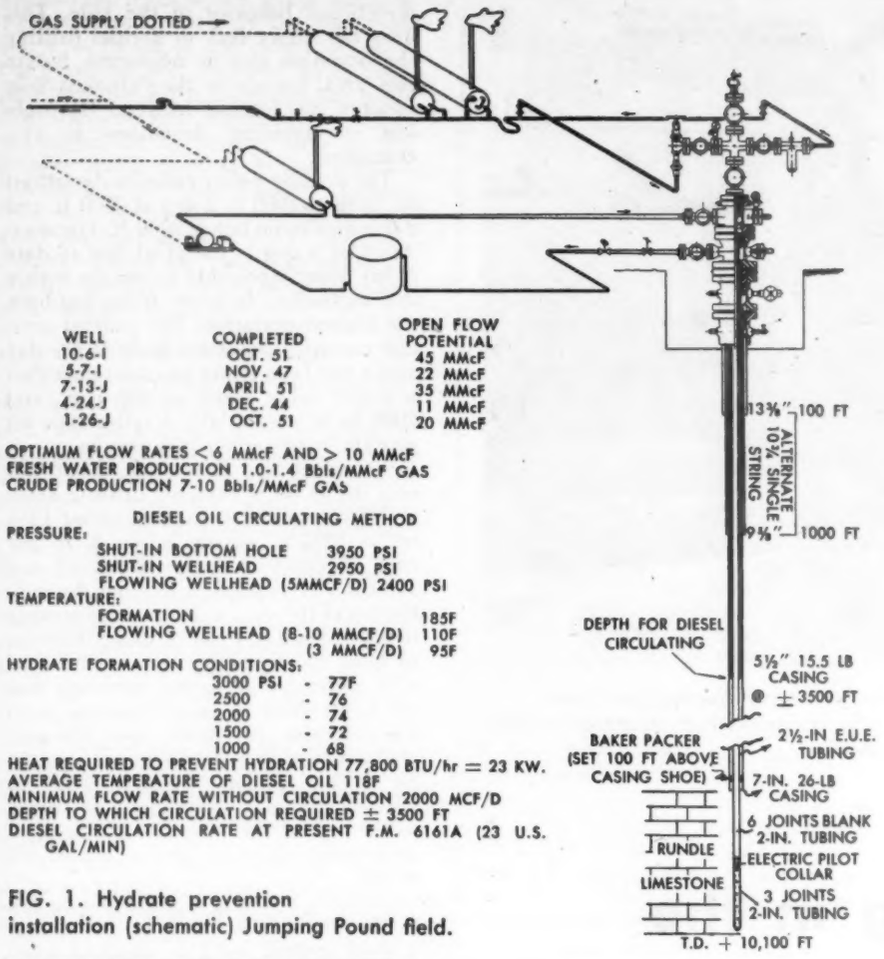
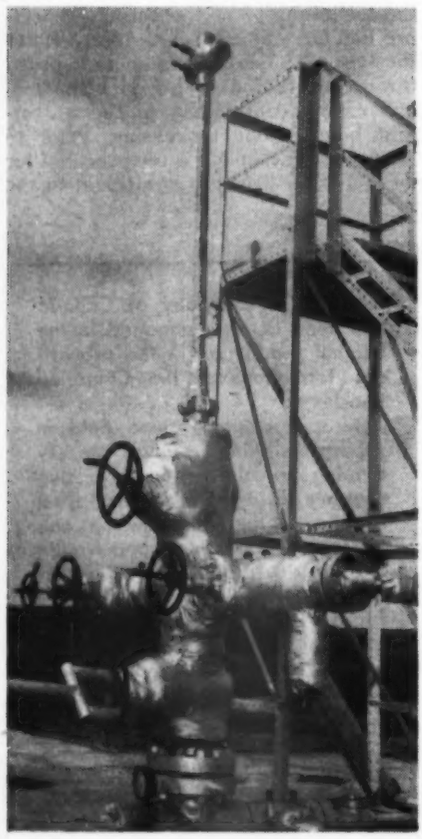

GAS SUPPLY DOTTED
WELL COMPLETED OPEN FLOW POTENTIAL
10-6-I OCT. 51 45 MMcF
5-7-I NOV. 47 22 MMcF
7-13-J APRIL 51 35 MMcF
4-24-J DEC. 44 11 MMcF
1-26-J OCT. 51 20 MMcF
OPTIMUM FLOW RATES < 6 MMcF AND > 10 MMcF
FRESH WATER PRODUCTION 1.0-1.4 Bbls/MMcF GAS
CRUDE PRODUCTION 7-10 Bbls/MMcF GAS
DIESEL OIL CIRCULATING METHOD
PRESSURE:
SHUT-IN BOTTOM HOLE 3950 PSI
SHUT-IN WELLHEAD 2950 PSI
FLOWING WELLHEAD (5MMCF/D) 2400 PSI
TEMPERATURE:
FORMATION 185F
FLOWING WELLHEAD (8-10 MMCF/D) 110F
(3 MMCF/D) 95F
HYDRATE FORMATION CONDITIONS:
3000 PSI - 77F
2500 - 76
2000 - 74
1500 - 72
1000 - 68
HEAT REQUIRED TO PREVENT HYDRATION 77,800 BTU/hr = 23 KW.
AVERAGE TEMPERATURE OF DIESEL OIL 118F
MINIMUM FLOW RATE WITHOUT CIRCULATION 2000 MCF/D
DEPTH TO WHICH CIRCULATION REQUIRED ± 3500 FT
DIESEL CIRCULATION RATE AT PRESENT F.M. 6161A (23 U.S. GAL/MIN)
13⅜" 100 FT
ALTERNATE 10¾ SINGLE STRING
9⅝" 1000 FT
DEPTH FOR DIESEL CIRCULATING
5½" 15.5 LB CASING @ ± 3500 FT
BAKER PACKER (SET 100 FT ABOVE CASING SHOE)
2½-IN E.U.E. TUBING
7-IN. 26-LB CASING
6 JOINTS BLANK 2-IN. TUBING
RUNDLE
ELECTRIC PILOT COLLAR
LIMESTONE
3 JOINTS 2-IN. TUBING
T.D. + 10,100 FT

FIG. 1. Hydrate prevention installation (schematic) Jumping Pound field.



Christmas tree wrapped with insulating material for hydrate control. Lubricator and ladderway provide for injection of stick inhibitor.

scratcher spacing, which is about 20 ft. By this means, a particular portion of the walls of the well bore are cleaned and the chances of the cement channelling and poor bond are thereby reduced.

By employing a string of N-80 tubing and 6⅛-in. cutterheads the pay is diamond cored 250-300 ft to total depth. (The reason for coring is mainly one of obtaining reservoir data.) Three formation tests are employed when coring the limestone. The first is over the first 100 ft, the second for the 100-200 ft interval, and the third for the bottom portion. Total depth of the well is governed by the top of the underlying black limestone. To enable the maximum amount of information to be available, many well surveys are carried out before completing the well, such as electric survey, micro-logging, hole section gage, radio active logging, dip meter, and photoclimometer.

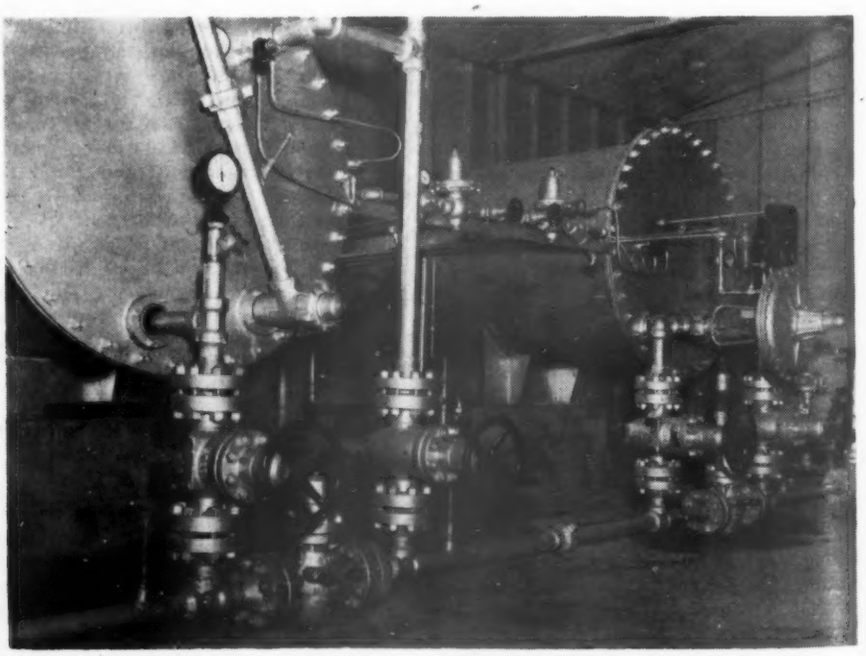
Completion Practice

The gas well is completed open hole and a general casing and tubing program is as follows: (See Fig. 1).

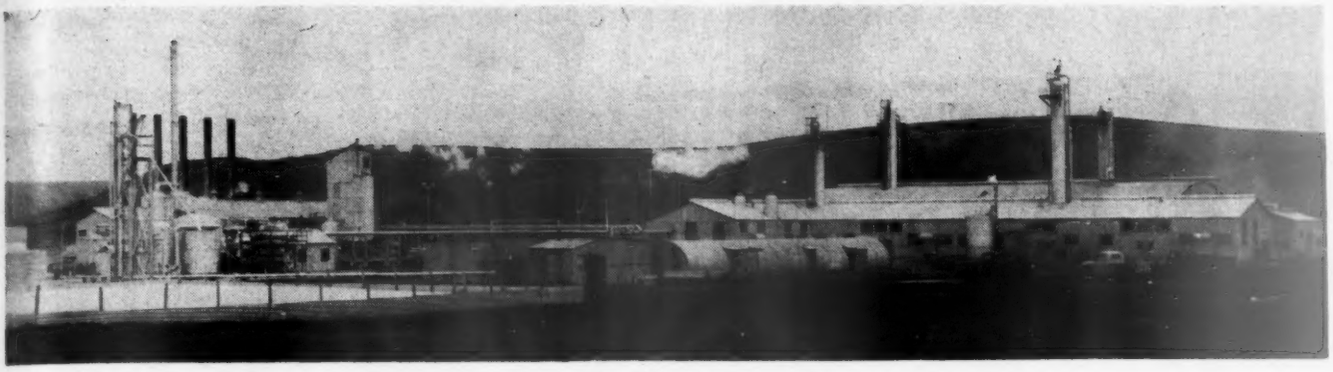
900 ft	13⅜	in.	54.5 lb J55
10,000 ft	7	in.	26 lb N80 extreme line
10,000 ft	2½	in.	6.5 lb N80 EUE (tubing)
150 ft	2	in.	blank tubing
100 ft	2	in.	perforated tubing including an electric pilot collar
3,500 ft	5	in.	15 lb J55 casing is especially incorporated in the well for the circulating of hot oil.

It will be noted that a special 5-in. casing string is included for circulating hot oil in a closed system, which is for the prevention of hydrate formation within the tubing and surface equipment. (This will be discussed later).

On completion of the formation tests, the well is given a general acid wash, which is followed by a series of selective acidizations of the upper and lower porous zones. A production test is performed after each acidization.



Two raw gas heaters for maintaining produced well gas above the hydrate temperature. The heater shell contains inhibited salt water solution and pressure reduction is taken through a split pass in th heater.



Jumping Pound gas scrubber and extraction plant. Elemental sulphur is extracted from the produced petroleum.

A production packer is then set in the 7-in. casing at about 100 ft above the top of the pay. The tubing is backed off from the packer and is laid down. The next stage is the running of a 5-in. casing string to 3500 ft. A new string of 2½-in. tubing is now picked up complete with a gas anchor on the bottom. The gas anchor is composed of, from the bottom up, 3 joints of 2-in. tubing perforated with 1¼-in. holes, electric pilot collar, and 6 joints of blank 2-in tubing. The tubing is run-in and made-up in the retainer packer set 100 ft above the pay. The well is swabbed dry and is brought in to production.

Hot Oil Circulation

Sub-zero climatic conditions in the winter months create many operational problems and one of these is the maintenance of continuous production. On a high volume producing gas well such as is found in Jumping Pound, severe icing would occur at the well head unless preventive measures were taken. The measures serve as a restriction against a pronounced process of refrigeration.

Although a Jumping Pound well at a normal producing rate of 6,000,000 cu ft of gas per day will flow without hydrates forming in the tubing, after a shut down period hot oil circulation is necessary for putting the well on production.

In addition, cold Canadian winters aggravate conditions causing hydrate formation because the normal temperature differential of the effluent and the atmosphere is so great, and the gas expansion so large, that within a short space of time the well automatically shuts itself off due to the excessive ice formation around the well head. The ingenious hot oil circulation method prevents any ocurrence of either hydrate formation within the well or ice at the well head.

Under certain producing conditions, hydrate formation will occur. These conditions are listed for the Jumping Pound field in the tables of Fig. 1. To overcome the problem effectively, two stages are involved in getting the well production to the field's gas processing plant.

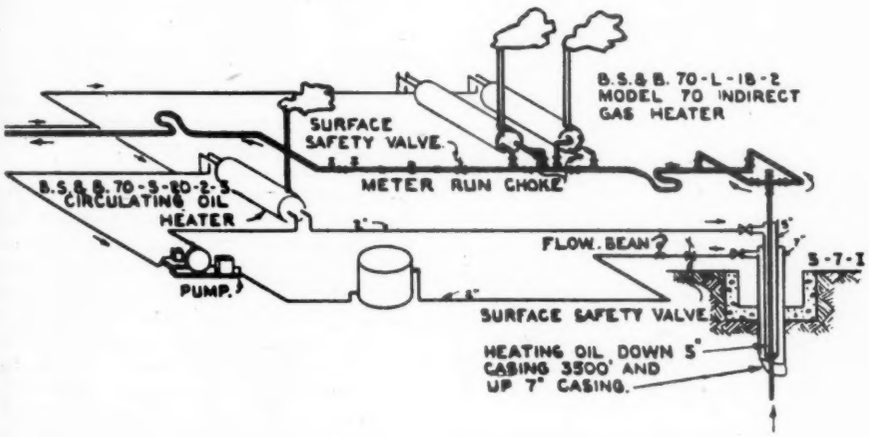


FIG. 8. Typical well head installation.

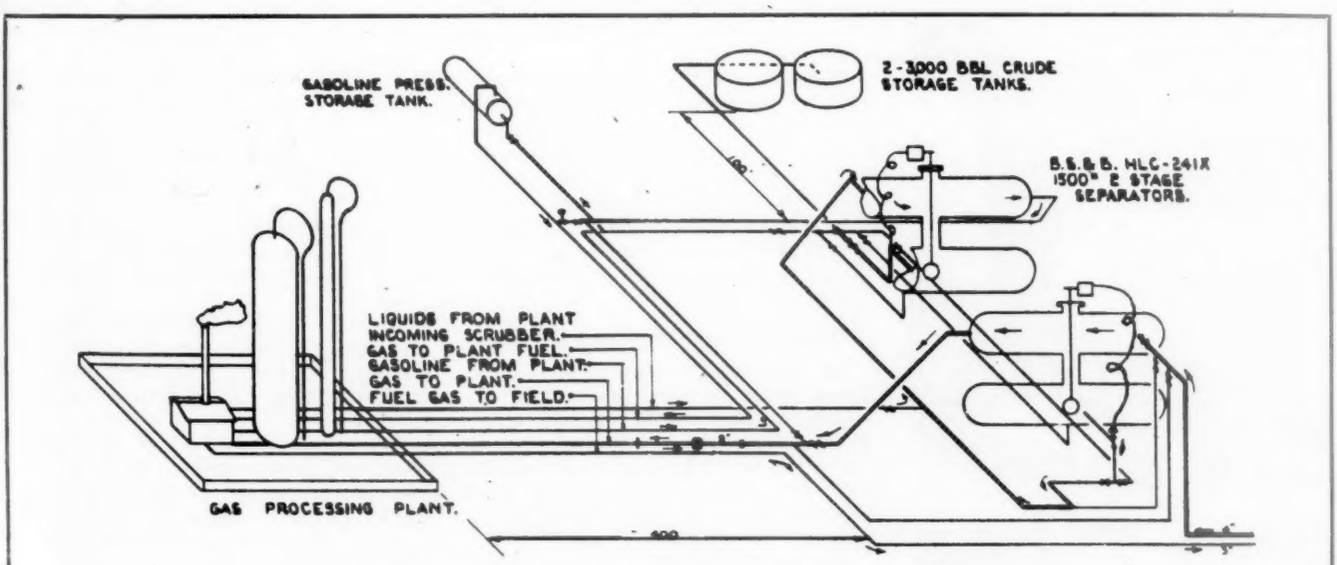


FIG. 3. Gas-gathering line separators — Jumping Pound field.

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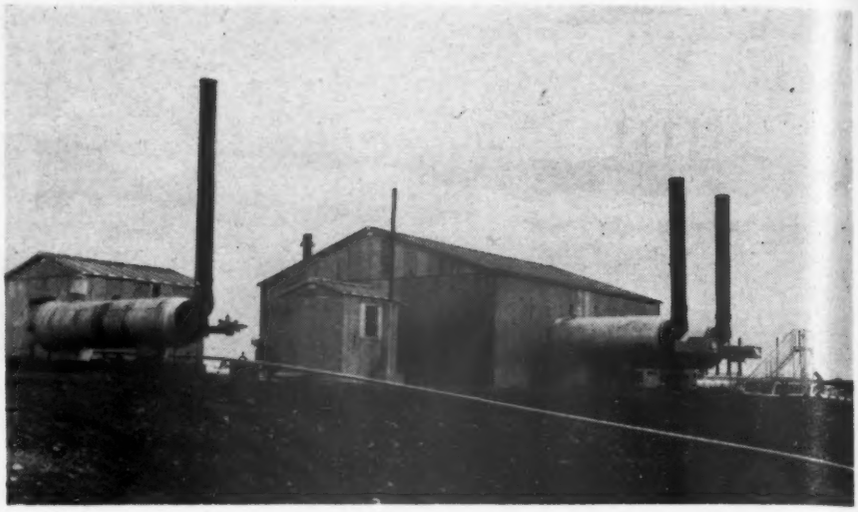

Well site surface heating equipment consisting of two raw gas heaters (right), and one diesel oil heater (left) for "hot oil" circulation in well.

Stage 1. Hot oil installation at well head area. (Spasmodic usage)
Stage 2. Gathering system installation (Continuous heat supply)

The first stage is within the well head area and is the hot oil circulating installation, which is not continuously required, its uage is dependent upon operational conditions. The second stage is at the gas gathering installation where a continuous and constant heat supply is maintained for treating the produced gas before it is finally received at the main process plant.

When required, diesel oil is pre-heated to 100 F and is circulated down the annulus between the 2½-in. tubing and 5-in. casing, and up the annulus between the 5-in. and 7-in. casing, at the rate of 23 gal per minute. (See Fig. 1). In order to prevent hydrate formation in the tubing, the circulating depth for the hot oil is 3500 ft.

Under the most adverse conditions the circulating temperature of the diesel oil is sufficient to reach satisfactorily, via a 5-ft buried flow line, the gas gathering system. Here heat treatment is applied irrespective of whether the hot oil system is in operation or not.

The second stage is thus: Under normal circumstances, the produced gas leaves the well head at 2700 psig and 90 F. At the gas gathering installation, on the second passing through of the first heater, the gas is choked to 1200 psig and at the inlet of the second heater, it is choked to 850 psig. The gas enters the gathering line at 850 psig and 140 F. (See Figs. 2 and 3).

Reservoir and Production Data

The production formation of Jumping Pound is the Rundle limestone (Mississippian), which is subdivided into three distinct zones. First, is the upper porous which is some 40 ft thick, and is followed by a 100 ft middle dense section, and last there is the 140 ft thick lower porous interval.

The productive porosity is secondary and is essentially vuggy and vesicular. Fracturing is present, but it is not considered to have any influence upon the productive capabilities of the reservoir. The average porosity ranges from 5 to 8 per cent and the permeability is in the order of 0.7 md. The original BHP was approximately 3950 psi. The crude is a wet gas condensate and yields 8 bbl naphtha, 4 bbl gasoline, and 1¼ short tons of elemental sulfur per million cubic feet of gas. The gas has a maximum hydrogen sulfide content of 5.0 per cent and corrosion inhibitor[2] is used to protect well equipment.

The total cost for successfully completing a gas well is in excess of $400,000 with an additional expenditure for special surface equipment and installations. A well is prorated to 25 per cent of its open flow potential and the present daily average production for the field ranges between 10 and 25 million cubic feet dependent upon demand. (The open flow potential of an average completion is approximately 30 million cubic feet per day). The production from Jumping Pound centers at the recently opened gas scrubber and sulfur extraction plant, which is the first extraction plant to be operated in Canada for obtaining elemental sulfur from natural gas. Four products are obtained at the plant:

1. The residue gas goes to Canadian Western Natural Gas Company for domestic consumption in Calgary, requiring a 20-mile pipe line, and for the town of Banff through a 50-mile pipe line.

2. The condensate is transported by road to a Canadian refinery.

3. The gasoline is sold to a local concern.

4. The extracted elemental sulfur is trucked 15 miles to the railroad at Cochrane, from where it is transported 600 miles by box car to British Columbia paper mills.

After a period of 14 yr, the original conception that commercial oil and gas lay in the difficult Foothill area of the Rockies near Calgary has materialized to the extent that in a one year period, production was increased by nearly 300 per cent when 5 billion cubic feet of gas was produced. * * *

[2]Kontol.

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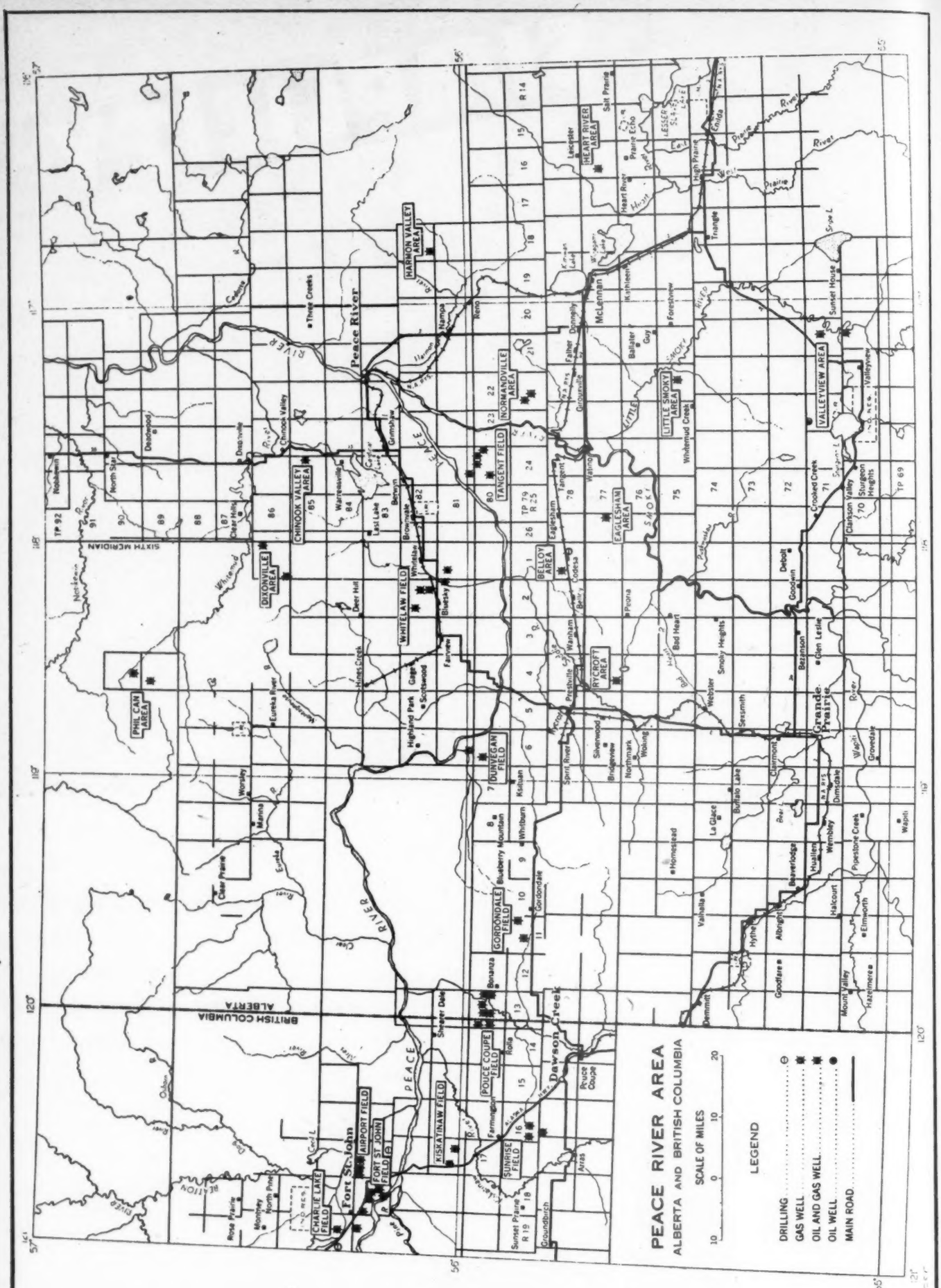

RELATION OF PEACE RIVER AREA TO ALBERTA AND EASTERN BRITISH COLUMBIA.

LARGEST CANADIAN GAS RESERVE TO DATE IS DEVELOPING

Vast Peace River area in general to be slated for greatest gas drilling campaign in Canadian petroleum history

L. O. ROWLAND*

WHAT will probably become the largest natural gas reserve in Canada has been proved in the Peace River region of northeastern British Columbia, within the phenomenally short space of eight months. This is the principal conclusion of the latest report on natural gas reserves, covering the Peace River region of British Columbia and Alberta exclusively, August 31, 1952, and released in the latter half of October. The report was compiled by Canada's top gas reserve estimating team, Dr. G. S. Hume and Alexis Ignatieff.

Since the completion of Peace River Allied Fort St. John No. 1 wildcat, 1sd 1-9-83-18W6, as a natural gas discovery in December 1951, the concentration of development and extension drilling with seven rigs at work for the most part of this year, has resulted in the outlining of a structure whose probable length was calculated at August 31 to be at least 20 miles. Since the cut-off date for the report, a five mile extension success has proved a major addition to the 11¾ miles confirmed by actual drilling previously for the Fort St. John field, and has indicated that the reserve figure of 1281 billion cubic feet estimated by the authors of the report was very conservative. Dr. Hume, director general of scientific services for the mines branch, department of Mines and Technical Surveys of the Dominion Government, and Ignatieff, chief of the fuels division of the same department, have collaborated on several previous natural gas reports and are highly reputed.

Summarizing the conclusions derived from an elaboration of structural and stratigraphic information, the report points out that the large reserve already established as proved and probable has been developed entirely from zones in the formations above Mississippian age. It suggests that evidence for continued increase in structural closure at increasing depth through the upper formation gives great promise of further discoveries in Mississippian and Devonian beds. These strata are present in other parts of the Peace River area and offer "exceptionally favorable structural conditions in the Fort St. John field for exploration by deeper drilling." Thus it is concluded that the undeveloped gas reserves in this structure are probably exceedingly large, total reserves are likely to be at least doubled by sufficient development, and the field will likely have a larger reserve than any other structure so far found in western Canada, including Pincher Creek, now rated Alberta's largest.

The Fort St. John reserves have been the greatest factor in establishing a total proved and probable reserve of 2506 billion cubic feet in the border-straddling northern region of the two provinces, amounting to more than half the entire reserve and 80 per cent of the British Columbia reserve. If the two closely related structures known as the Airport and Charlie Lake fields are included, the composite field has 1446 billion cubic feet proved and probable, or more than 90 per cent of the B. C. total and nearly 60 per cent of the combined aggregate. British Columbia is credited with a total of 1585 billion cubic feet, Alberta with only 921 billion cubic feet.

Economics

The economic significance of the enormous Peace River region reserves, which have been more than tripled from the estimate given last fall by various experts testifying at export permit hearings in Alberta, is their availability as a source of supply for the first major natural gas export pipe line out of Alberta, proposed for completion by next winter by Westcoast Transmission Company, Limited. This line, for which permission has now been granted by all the Canadian authorities having jurisdiction, awaits only Federal Power Commission approval of a proposed line to be built by an American subsidiary to serve Pacific Northwest cities with Alberta and British Columbia gas. Applications by this company (Trans Northwest) and by Northwest Natural Gas Company, a competitor seeking to bring Texas or Four Corners gas to the same region, were before the FPC for decision at the end of October.

As far as Canadian authorities are concerned, all British Columbia gas is available immediately for the proposed Westcoast Transmission Company, Ltd., line, and the Alberta Government has granted a qualified export permit for 210 billion cubic feet during the first five years of the line's operation, from the Alberta side of the Peace River region, with assurance that further exports of at least the same rate will be guaranteed for an additional 17 years. This is the only region of Alberta in which any gas has been declared surplus to the needs of the province, and is likely to remain in that category for some time.

The Hume-Ignatieff report contends that there is significance for the probable future discovery rate in the fact that, with the exception of the Pouce Coupé field, all the development in the Peace River area, including completion of wells in 18 separate areas, has followed the discovery of oil at Normandville in 1949. "It is remarkable," the authors say, "that without an assured available market so much gas has been found in so short a time." This is particularly notable in a country where large tracts are difficult and expensive to explore on account of the relatively poor development of access roads.

This situation points up the fact that the incidence of discovery for wildcat wells has been much higher in the Peace River area than is generally the case elsewhere. This could only occur, the authors conclude, in an area where the prospects for successful gas completions are very favorable and there is thus good reason to believe that a market outlet, which will stimulate further drilling, will produce a rapid increase in the already considerable gas reserves. The recent oil discovery at Sturgeon Lake, by Amerada Petroleum Corporation, is expected to help materially in this stimulus. The discovery was made in 90 ft of Devonian reef between 8914 and 9015 ft in depth.

Subsurface Information

A great deal of information about subsurface conditions has been derived from drilling to date, and the general geological picture is fairly well outlined. The report lists the principal producing formations and zones as follows, from younger to older ages:

Cadotte sandstone of Lower Cretaceous age up to more than 100 ft in thickness is widespread as a marine sand in the whole area and under favorable structural conditions for gas accumulation is of very good productive capacity.

Gething sandstone, really a separate formation in the western part of the area, is considered to have been deposited in near shore marine conditions with clay materials, hence is variable in character and lenses to shale. Although not as good a continuous reservoir sand

*Editor, *Oil in Canada*.

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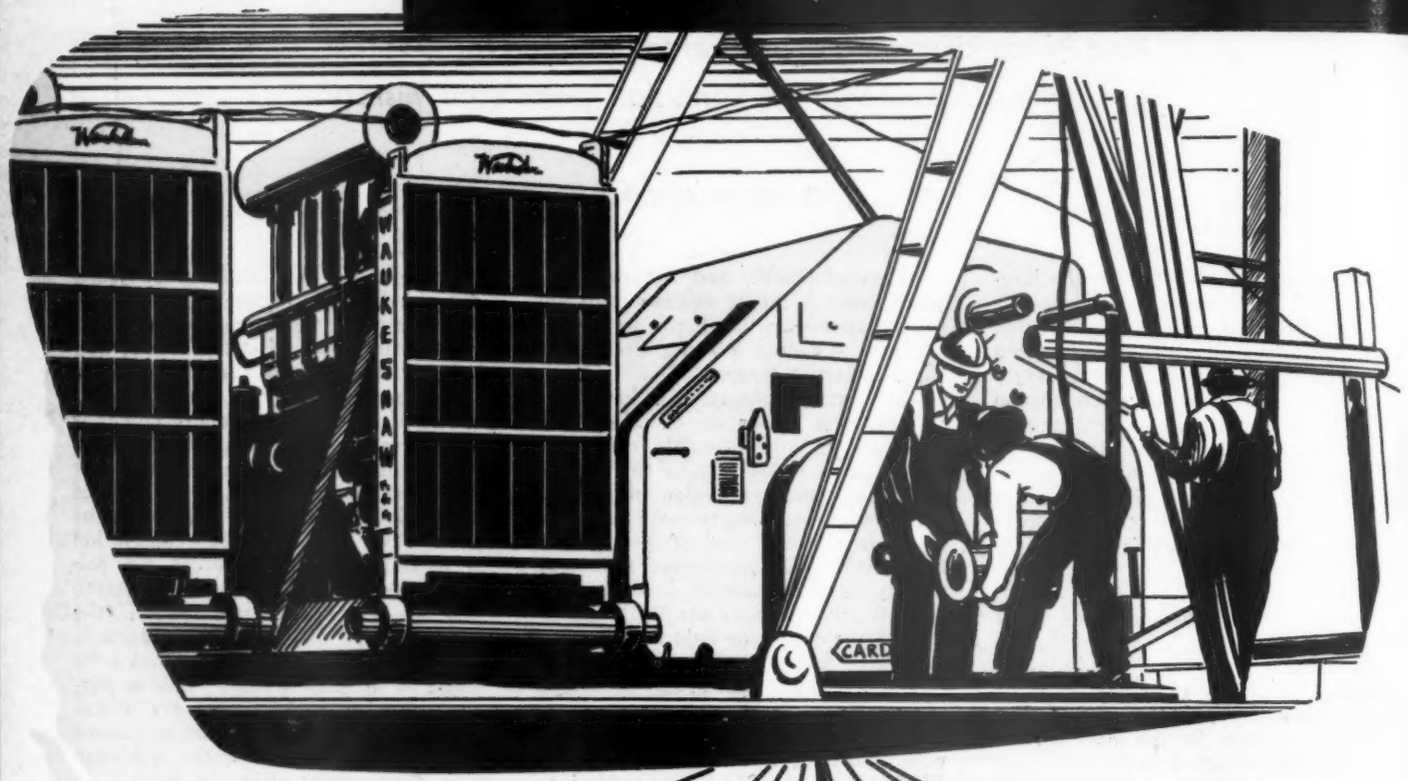

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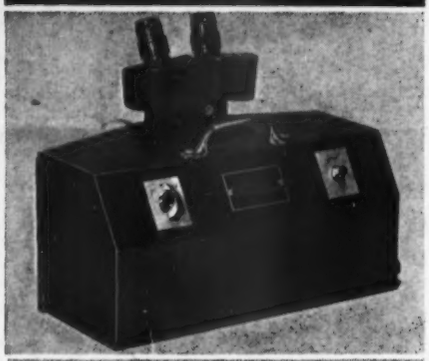

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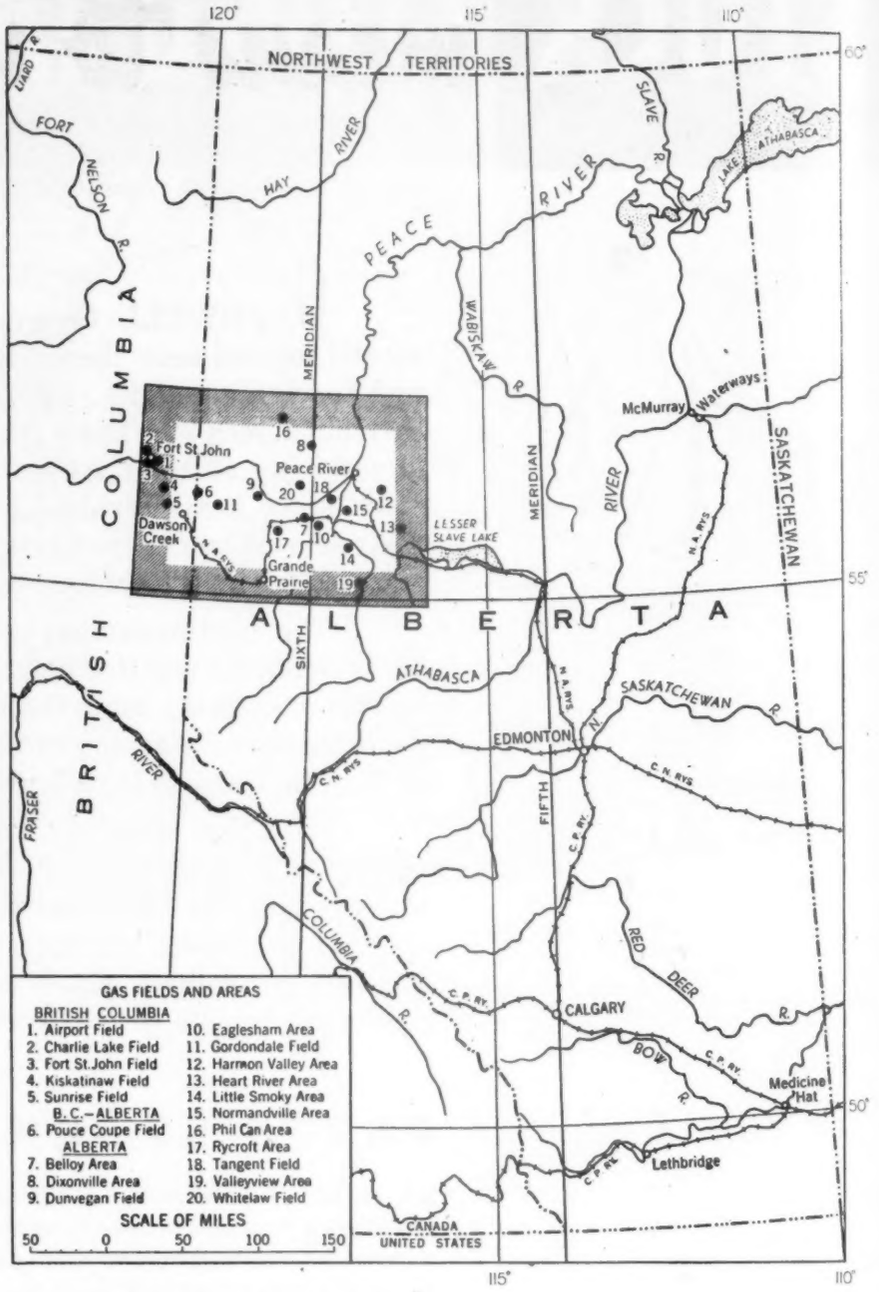


Index map showing gas fields in Peace River area.

as the Cadotte, it is productive in a number of areas.

Cadomin sandstone is productive in some areas, with relatively loose sands of good porosity. Owing to the low salt content of water in this zone, where it is water-bearing, electrolog analysis may give an indication similar to what would be shown by a gas or oil zone, and some interpretational difficulties have been caused by this factor. In the Fort St. John structure and in other fields it has been found to have a rather steeply plunging gas-water interface. This is important, the report explains, in evaluating gas content of the zone and in making drillstem tests in flank wells where indications are favorable but where the possible productive zone is lower in elevation than the water-gas line in higher wells.

Triassic formation, a highly variable series of beds that thicken rapidly to the west and southwest of Peace River town, consists mainly of limestone upper beds in the productive areas, and of good continuous sands in the middle beds. The latter are 50 ft thick in the Fort St. John field, are expected to be present in every well drilled in that area, and will be limited in the productive part only by porosity and structural height in relation to the gas-water interface. The former are calculated to contain almost one third of the proved and probable British Columbia reserves, with a porous productive zone varying from 20 to 65 ft in thickness in the Fort St. John area. The top of the Triassic is erosional and bevelled, so that in drilling various areas the same zones are not likely to be encountered at the same depth below the top of the formation.

Permo-Pennsylvanian dolomites have been penetrated by several wells in the Peace River area, but only in the Fort

St. John area has the formation been proved as yet to have prolific production. In the No. 4 well it is 370 ft thick, but in the No. 5 well was found to have the porous top entirely eroded off before deposition of the younger beds. Top of the formation is found around 6200 ft in this field, and in the No. 4 well, one of the highest rated producers in the field on initial potential test, was found the interesting feature, as disclosed in cores, of three separate zones divided by thin horizontal separation planes which are expected to be capable of greatly facilitating the movement of gas to the well bore. The productive capacity is "exceedingly large," the No. 4 well having flowed at rate of 29,000,000 cu ft per day with bottom hole pressure of 2550 psi.

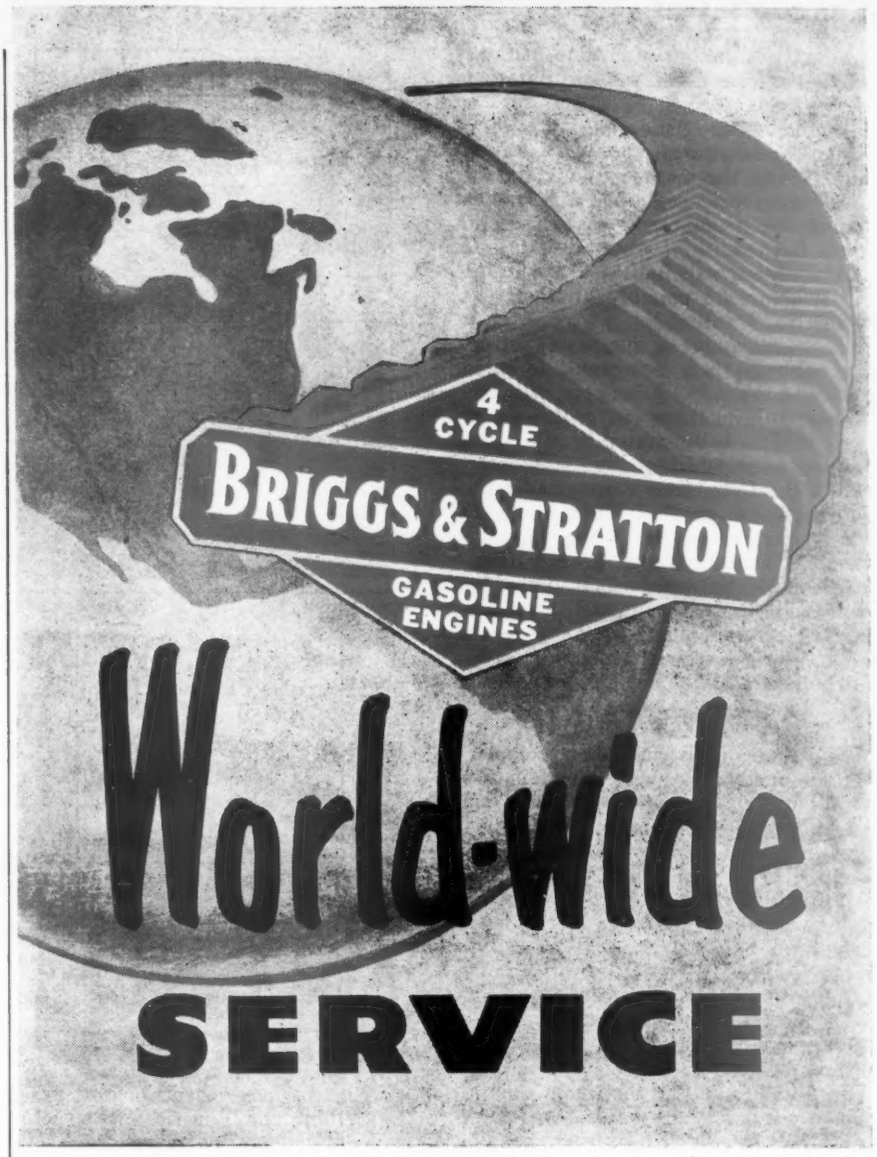
Mississippian limestones and dolomites, penetrated by many wells on the Alberta side, have not yet been penetrated by any in British Columbia, but it undoubtedly has a large thickness in this area, probably in excess of 2250 ft in the Fort St. John area, with the upper zones likely to be productive in many wells. On the Alberta side, gas production indicated from this formation at Imperial Belloy No. 2 discovery well and at Hudson's Bay-Union Eaglesham No. 1 discovery well 11 miles southeast makes the possibilities appear good for its extending over a considerable area. It is believed one of the productive zones in the Eaglesham well may correlate with a zone that yielded gas in the Belloy No. 2.

Devonian limestone upper beds and dolomite lower beds, underlain by a basal sandstone that rests directly on the Precambrian basement, have been reached and penetrated by a few wells in the Peace River area of Alberta, and two oil discoveries at Normandville and Sturgeon Lake, the latter in reef formation, have created much interest in the prospects of the Devonian. Drilling undoubtedly will be stimulated, the report suggests, and the discovery rate for gas can be expected to be accelerated.

Prospects and Reserves

Particular emphasis is placed by the authors on the report on the excellent prospects of the Fort St. John field as a very large reserve. This opinion is supported by the proof, through drilling, that the three individual structures, all part of a general uplift in the area, are productive. There is strong reason to think that the Airport and Fort St. John structures are a unit at depth, but further drilling will be needed to confirm geological and geophysical interpretations.

Seismic exploration has some limitations due to the nature of the depositions, as silts have filled in former valley courses and lower lying topography in the Fort St. John area at the time of their deposition. Thus, the report points out, the southeast end of the structure is not fully outlined and a known southeast plunge may be only into a saddle between this and another structure lying immediately to the southeast of the trend. (Completion of the No. 12 well, which has confirmed presence of com-



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mercial gas in the higher formations, will give considerably more information.)

Similarly the seismic picture is lacking to the southwest, although data are available on the northeast flank. To the northwest, the seismic data had confirmed the structural trend for several miles beyond No. 16 well at the date of the report, and indicated a continuous structure for possibly 20 miles west of the No. 9 well alone.

The indication of increasing structure with depth is interpreted to mean an origin in the Palaeozoic era with successive rejuvenations in more recent periods. This is illustrated by structural contour maps which show a 10-ft interval on the Cretaceous corresponding to 50-ft spacing on the Triassic and to 100-ft interval on the Permo-Pennsylvanian. "This structural growth downwards makes the prospects in the as yet untested Mississippian and Devonian beds exceedingly attractive for properly located wells," say the authors.

The extraordinary attractiveness of the Fort St. John structures is further enhanced by the fact that already, with only a dozen wells completed, commercial production has been found in two Lower Cretaceous sands (Gething and Cadomin), Upper Triassic, three zones of Middle Triassic and three zones of Permo-Pennsylvanian. The Upper Triassic, which has been found in more wells than any other formation in the field, has shown thicknesses of 31 to 65.1 ft in six wells, with average porosity ranging from 6.2 to 12.7 per cent.

Summing up the Fort St. John field, the report considers that its development provides "by far the most impressive results to date in the whole general region." It points out that the structural conditions as revealed by seismic exploration and drilling are extremely favorable, but there is an unusually large number of productive horizons with excellent prospects at greater depths than yet reached by any well in the area.

The reserve estimate is based only on drilled wells and does not assess the under-developed part of the structure, which as revealed by geophysical exploration "is even larger than that on which the wells are now either completed or being drilled." "Thus," it explains, "an exceedingly large reserve is possible in this one area, a condition which would be very advantageous from the standpoint of operating costs."

On the Alberta side of the region, the largest proved and probable reserve is listed for the Tangent field, which was discovered in 1951 by the Hudson's Bay-Union North Tangent No. 1 wildcat, which blew out at a depth of 3274 ft and flowed wild at an estimated rate of 50,000,000 cu ft per day until controlled. Both the Cadotte and Gething sands are gas bearing. The eight wells drilled in the vicinity of and on the uplift have confirmed the surface structure as determined by previous core drilling. The five wells which have been successful establish a reserve calculated at 283 billion cubic feet.

The Whitelaw field, discovered in 1950 by Shell B. A. Whitelaw No. 1 wildcat, disclosed occurrence of gas in the Gething and Triassic. The structure was determined by seismograph, and there is a possibility that Normandville, Tangent and Whitelaw uplifts may be associated with a deep seated fault that cuts the Permo-Pennsylvanian beds but not the younger strata. The latter, due to the uplift, are draped over the structure caused by the deeper fault. Although the discovery well was put on production for oil, from the top of the Permo-Pennsylvanian formation, extension drilling has resulted in completion of four additional gas producers across a distance of seven miles. The Gething under favorable conditions is gas-bearing at less than 3000 ft depth, and the authors of the report consider that the productive prospects are good in the middle of the three zones in this formation.

The Triassic is composed of three zones, of which the upper is gas-bearing in all five successful wells. The middle is separated into two areas by a very narrow syncline, leaving the discovery well and two non-commercial offsets in one area of accumulation, while the three successful wells southeast of the discovery belong to another area. The lower zone is found only in the discovery and the successful well one mile south, which constitute separate areas.

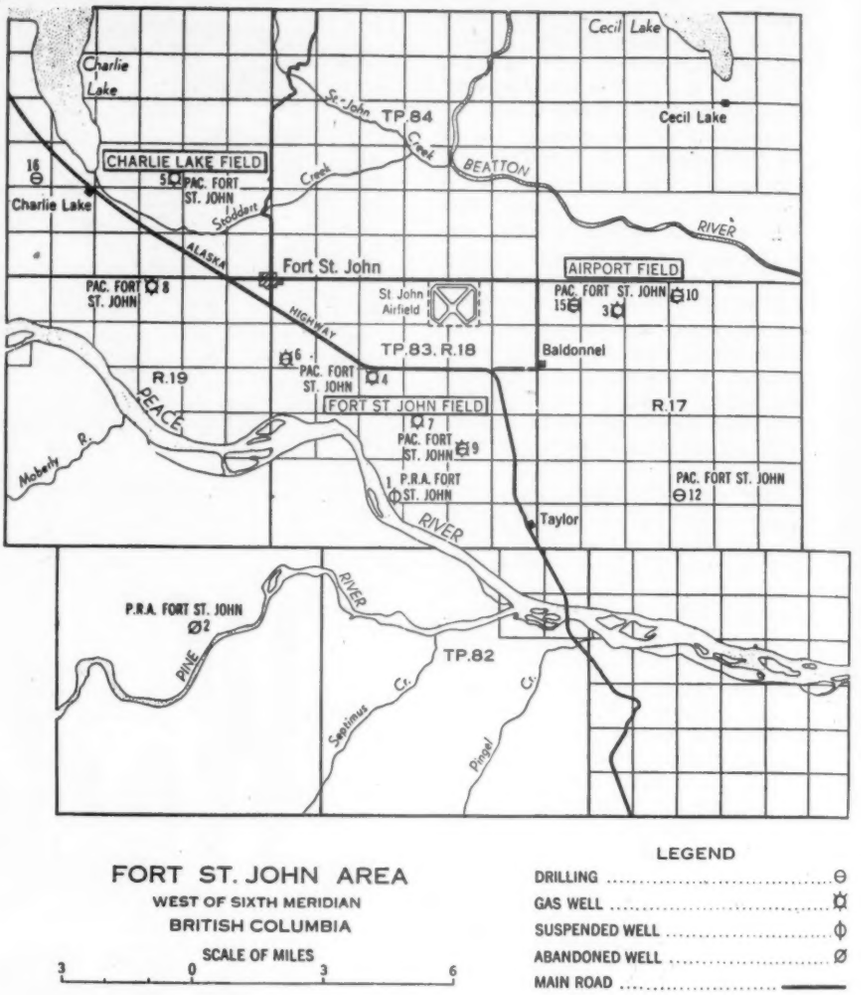
Permo-Pennsylvanian gas in this field so far has no appraisal value.

The total proved and probable reserves assigned to the field, 201,000,000 cu ft constitutes the second largest individual field reserve on the Alberta side of the Peace River area.

The Dunvegan field (Hamelin Creek) was discovered in 1951 by Hudson's Bay Union Texaco No. 1 wildcat after core drilling had established the presence of a structure. Gas in the Cadotte sand and in the lower part of the Gething is believed the equivalent of the Cadomin in other areas. Depth is less than 3800 ft. Total thickness of the Cadotte sand is 180 to 190 ft, in two zones, with good porosity. On the basis of only two completed wells, a reserve figure of 123 billion cubic feet has been assigned to the field. (Recent success of H-B. Union Dunvegan No. 3 extension, 1sd 5-19-81-4W6, in the Cadotte, indicates a 7-mile extension.)

The only other Alberta side field for which more than 100 billion cubic feet has been estimated is Pouce Coupé, which overlaps the British Columbia boundary but has some doubtful features that have not yet been resolved by drilling. By far the oldest field in the area, Ponce Coupé was discovered in 1923 with completion of a well in the Cadotte sand, but no substantial development took place until 1948, when the Peace River Natural Gas Company, affiliate of Pacific Petroleums Limited, drilled several wells to establish the producing area.

An interesting situation on the Brit-



FORT ST. JOHN AREA
WEST OF SIXTH MERIDIAN
BRITISH COLUMBIA

SCALE OF MILES
3 0 3 6

LEGEND
DRILLING ..... ⊖
GAS WELL ..... ☼
SUSPENDED WELL ..... ⊕
ABANDONED WELL ..... Ø
MAIN ROAD ..... ———

Sunray Oil Corporation officials visited the Fort St. John area of northeastern British Columbia to get a first-hand impression of drilling operations. Left to right are: L. M. Clark, Pacific Petroleum vice president in charge of exploration; Frank M. McMahon, chairman of Pacific; Senator J. W. deB. Farris, of Vancouver; Lloyd Gilmour, Eastman, Dillon and Company, underwriters of Westcoast Transmission; George L. McMahon, president of Pacific; Norman R. Whittall, of Vancouver, a director of Pacific; John McMahon; and C. H. Wright, chairman of Sunray and a director of Pacific.

ish Columbia side, which has caused the authors of the report to limit severely the amount of reserves allocated to this side, is the presence of water in the Cadotte sand. Whether this intrusion is due only to faulty completion, or is from the possibly productive part of the sand, could be determined by the drilling of another development well between the two productive wells, "with a reasonable chance that such a well would prove productive," or by reworking the first two wells.

Structurally, the water-bearing wells are higher than a non-commercial well five miles west that did not find water. Based on structural conditions only, the field "would be expected to extend much farther west, although it may be limited by a change in the character of the reservoir sand such as would be expected in a stratigraphic trap." Subject to determination of the source of the water intrusion, a considerable area in British Columbia is potentially productive.

A number of other Alberta fields are discussed in the report, but owing to lack of development drilling it is impossible for the authors to place more than a nominal reserve valuation on them. Among the leading prospects is Gordondale, discovered only this year by Canadian Fina Royalite No. 2 well which found 33 ft of productive Cadotte sand with an indicated good yield and initial potential of 4,000,000 cu ft. Discovered by structural core drilling, and indicated as being on the general structural trend from the Fort St. John field, through Kiskatinaw and Pouce Coupé, the field "has considerable promise of developing into a substantial gas-bearing area." The Pouce Coupé productive Cadotte sand is considerably higher structurally, so that a saddle on the trend exists between it and Gordondale.

The Belloy-Eaglesham area, with only one productive well at each point 12 miles apart, is nevertheless fairly well defined by structural information from these wells and several dry holes. The structural information suggests that for a considerable area surrounding each well the prospects for Mississippian gas production are good, but only a small area for each can be considered as proved. A high structural area in the Mississippian is indicated around each of the wells, Imperial Belloy No. 2 and Hudson's Bay Union Eaglesham No. 1. (A four mile northeast extension from the latter, currently drilling, may provide considerable further information. This well was not begun at the date of the report.)

The Rycroft field, discovered in 1952 by Pacific Gas Exploration Rycroft No. 1 well, contains gas in the Cadomin sand at the base of the Gething formation. The sand is 35 ft thick, with 20 per cent porosity, and "represents a considerable gas reserve." As the well was also an oil discovery, the gas will not be available until during and after the oil production period. The field, however, has the merit of being available to serve the town of Rycroft and excess could be utilized to feed into the main line of Westcoast Transmission Company.

The structure of the field is indicated, from seismic information and the first well, as a trap due to faulting on the northeast edge in the Palaeozoic. This interpretation is favorable for production in lower beds as well. Since the date of the report, a two-mile northwest stepout has discovered gas in the Cadomin.

Although the Hume-Ignatieff report does not intimate specifically, it has been stated on many occasions by top officials of the Pacific Petroleums and Peace River Natural Gas group that Alberta Government policy with reference to surplus gas has retarded development in that province and compelled a shifting emphasis to British Columbia since last fall. Briefly, the failure of the Alberta Government to declare surplus a larger amount of natural gas, and thus encourage greater exploration effort, is commonly being accepted by the industry as its justification for ignoring to a large extent the very promising structural and stratigraphic features of the Alberta side of the Peace River region. At the same time similar features on the British Columbia side are being exploited to the extent that, quoting a recent statement by president George L. McMahon of Pacific Petroleums, Limited: "Nearly every major oil company on the continent has acquired extensive holdings, the total of which now exceeds 35,000,000 acres."

Since the Fort St. John discovery, and particularly since the issue of the very limited export permit by the Alberta Government in March, British Columbia government exploration permits covering 24,000,000 acres have been added to the 11,000,000 acres held last fall, more than is under reservation in either Saskatchewan or Manitoba.

Development

The basic element in the entire current development of the Peace River area is the prospect of a large export pipe line. Without this economic foundation the geological and geophysical picture would not carry much weight, but with such a potent factor in the background, the phenomenal technical factors outlined in the report assume tremendous importance for any company seeking to enter the natural gas production business.

The relative scarcity of exploration and exploratory drilling that has been required to prove up one and one half trillion cubic feet in British Columbia can be discerned from the map. The small extent to which presently drilling companies have been able to explore ahead is evident from McMahon's reference to the fact that Pacific Petroleums and its affiliates are currently operating two seismograph crews continuously and that these crews have been successful in mapping several large additional structures, two of which are now being drilled.

As the most promising gas search area in western Canada, the Fort St. John field in particular and the Peace River area in general appear to be slated for the greatest gas drilling activity in Canadian history, on the basis of the facts disclosed by the Hume-Ignatieff report, the inferences and conclusions presented by the extremely competent and reputable authors of the report, and the prospect of a pipe line outlet to markets that (according to figures compiled by the sponsors of Westcoast Transmission Company) are within one thousand miles distant. The exact mileage to Portland, Oregon, from the Fort St. John field, 960 miles, is stated by this source to be the shortest route to the Pacific coast from any available gas source on the continent. The potential market is upwards of 300,000,000 cu ft per day. * * *

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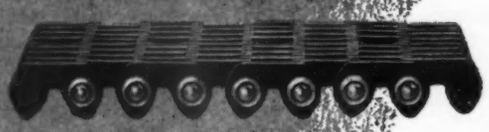

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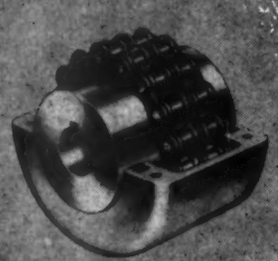

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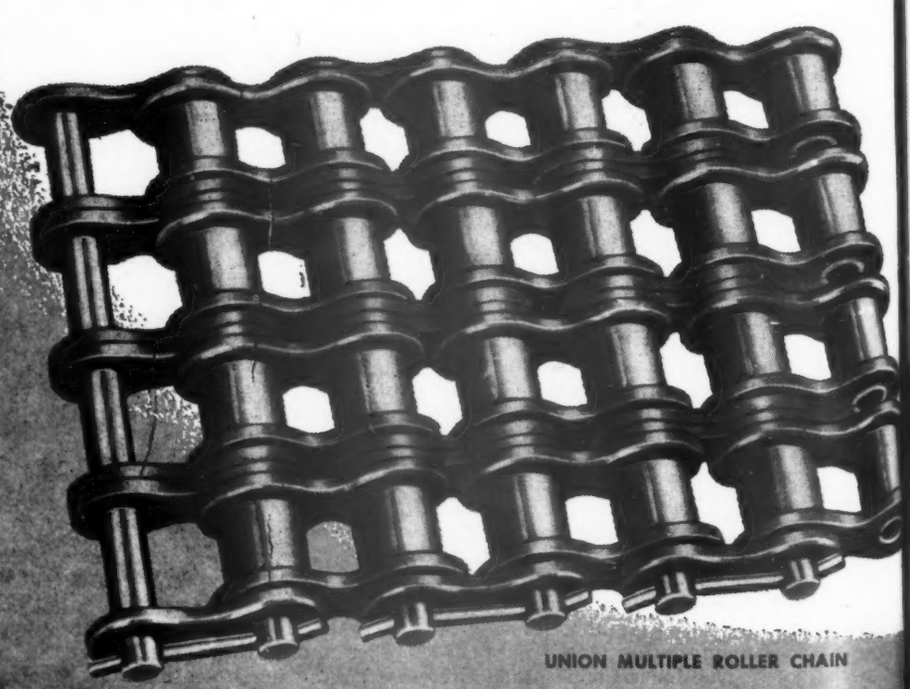

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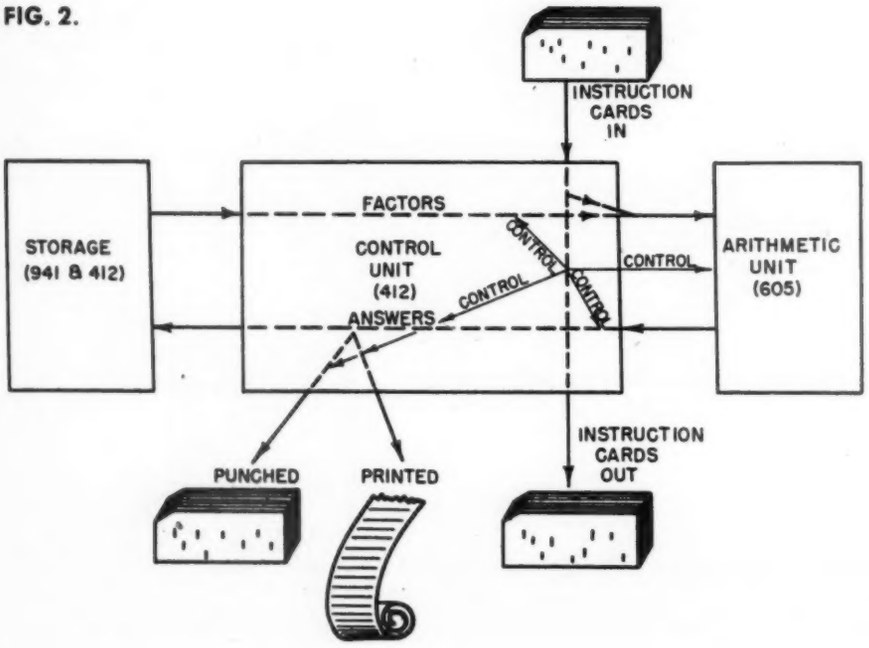
FIG. 2.



FOR several years engineers in the petroleum producing industry have been experimenting with accounting equipment for use in solving the complex problems occurring in the technology of petroleum production. The Research Department of the Carter Oil Company has been experimenting with the use of accounting machines[1] in solving reservoir behavior problems. In July, 1952, Carter began using a card programmed electronic calculator[1] for this work. Mathematical calculations with the aid of this equipment differ from those previously made with other calculators[1] in that the calculations can proceed for a substantial number of different mathematical operations without human intervention.

The card programmed electronic calculator, usually referred to as the CPC, is made up of the 605 electronic calculating punch, the 412 accounting machine, and the 941 memory unit.* In handling the cards and getting the most out of the CPC some auxiliary equipment is used. This includes the key punch to prepare the cards, a sorter, a collator, and a reproducing punch. Fig. 1 is a photograph showing several of these units and Fig. 2 indicates schematically how the 412 accounting machine acts to route the numbers into the calculator and the solutions into the memory units or into the printing and punching devices. Sub-routines can be wired into the machines so that several arithmetic operations can be carried out automatically from a single punch in one of the instruction cards. The CPC can handle as many as 150 of these cards per minute. Each card contains sub-routine in-

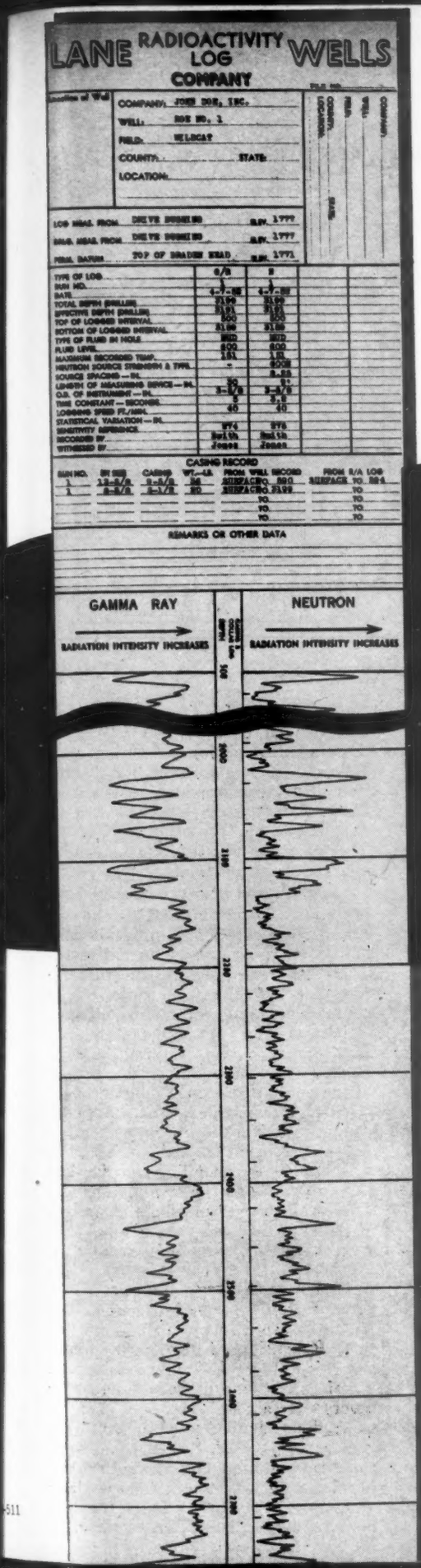
[1]IBM.

*The CPC installed at Carter has 2 of these 941 units.

The Authors

W. A. Bruce is assistant chief of research of Carter Oil Company. A graduate of Kentucky and Washington University, where he obtained his PhD in 1938, he worked for Ashland Oil in 1933 to 1935 and joined Carter in 1938. He was first research engineer and later head of exploitation research.

R. N. Bonner is research engineer in charge of the electronic computing group for Carter Oil Company Research Laboratory. He was graduated from University of Utah, Brown University, and obtained his MS from the University of Wisconsin, 1943.



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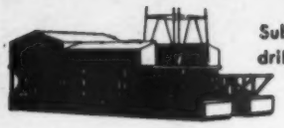
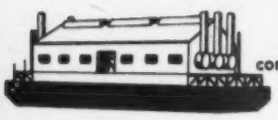


Submersible drilling barges

Tugs



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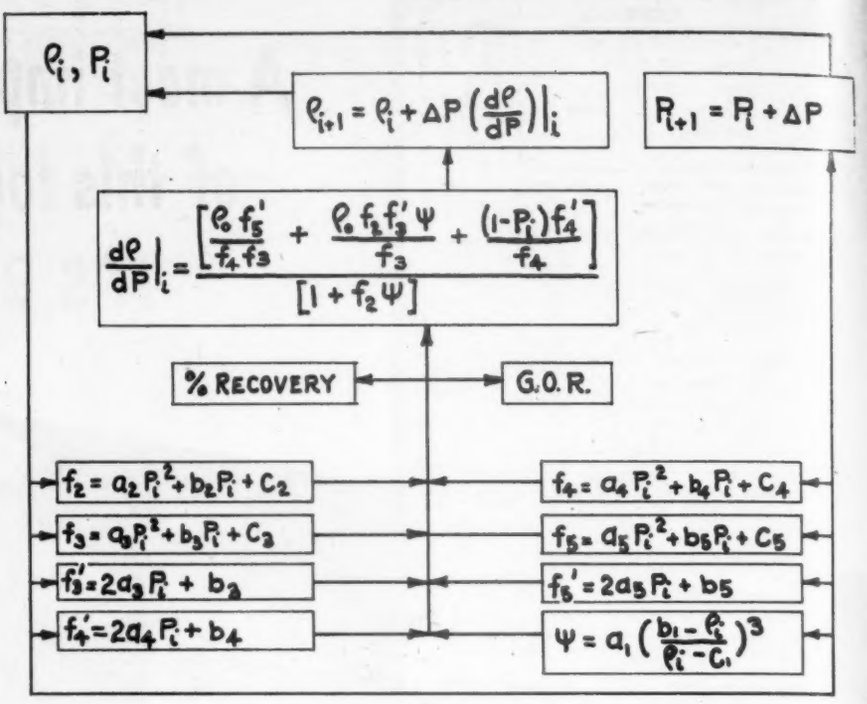
P_i, P_i
$P_{i+1} = P_i + \Delta P \left(\frac{d\rho}{dP}\right)\Big|_i$
$P_{i+1} = P_i + \Delta P$
$\frac{d\rho}{dP}\Big|_i = \frac{\left[\frac{\rho_o f_5'}{f_4 f_3} + \frac{\rho_o f_2 f_3' \psi}{f_3} + \frac{(1-P_i) f_4'}{f_4}\right]}{[1 + f_2 \psi]}$
% RECOVERY
G.O.R.
$f_2 = a_2 P_i^2 + b_2 P_i + C_2$
$f_4 = a_4 P_i^2 + b_4 P_i + C_4$
$f_3 = a_3 P_i^2 + b_3 P_i + C_3$
$f_5 = a_5 P_i^2 + b_5 P_i + C_5$
$f_3' = 2a_3 P_i + b_3$
$f_5' = 2a_5 P_i + b_5$
$f_4' = 2a_4 P_i + b_4$
$\psi = a_1 \left(\frac{b_1 - P_i}{P_i - C_1}\right)^3$

FIG. 3.

structions and numbers upon which the machine can operate.

By this method of organization of the machines it is not necessary to have special wiring for each problem. Thus the CPC with one general purpose floating decimal board can be set up so that problems such as those occurring in the production of a dissolved gas drive reservoir, a gas cap reservoir, or in the vapor-liquid equilibrium process can be solved simply by changing decks of instruction cards and numbers. Other types of problems involving the assembly and interpretation of data can also be handled with this equipment.

It is beyond the scope of this paper to describe how the CPC would be used to handle one of the more complicated problems for which it is particularly well adapted. It might be of interest to engineers, however, who are familiar with the conventional natural depletion analysis involved in studying dissolved gas drive reservoirs, to see how the CPC has been used on this problem. There are a number of different ways of handling the problem. For a reasonably complete solution about a man week of time is required using the slide rule, a desk calculator and graph paper. This problem has been set up for the CPC and the time necessary for this solution is less than one-half day.

Detailed steps for a solution are as follows: Starting with the liquid saturation at a given pressure, reservoir and fluid characteristic functions are first calculated by preassigned formulae. This gives the pressure dependent fluid characteristic functions f_2, f_3, f_4, f_5, f_3', f_4', and f_5', and also produces the ratio of relative permeabilities, as shown in Fig. 3; this requires 36 program cards, and takes about 23 sec for calculation. Then these functions are substituted in formulae for the gas-oil ratio, the per cent recovery, and the rate of change of saturation with pressure, as shown in Fig. 3. This requires 15 program cards, and 10 sec. Knowledge of the pressure of the pool after a short interval of production and knowledge of the rate of change of saturation with pressure at this point permit the calculation of the saturation corresponding to the later time, as shown by the formula in Fig. 3. These values of saturation and pressure at the later time can then be used to repeat this basic calculation cycle to find a saturation and a pressure at a third time. This basic cycle requires 53 program cards and can be completed in about 34 sec without human intervention. Repetition of this cycle permits the calculation of complete saturation, gas-oil ratio, and pressure versus recovery curves.

As this calculating equipment is at present being used, three people spend full time planning, coding, and running problems. In addition to these three, others are sufficiently familiar with the machine to plan and do essential coding for their problems.

The speed of the machine enables engineers to obtain solutions to complex problems in time for these solutions to be useful in guiding reservoir control.

* * *

☆ ☆ ☆

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Figures show that customers of the petroleum industry are very honest folk. The American Petroleum Credit Association, concerned with everything from one-dollar sales at the service station to shiploads of oil and products worth hundreds of thousands of dollars, says the average loss ratio, amounted to only one third of one per cent of total credit sales by some 20 firms.

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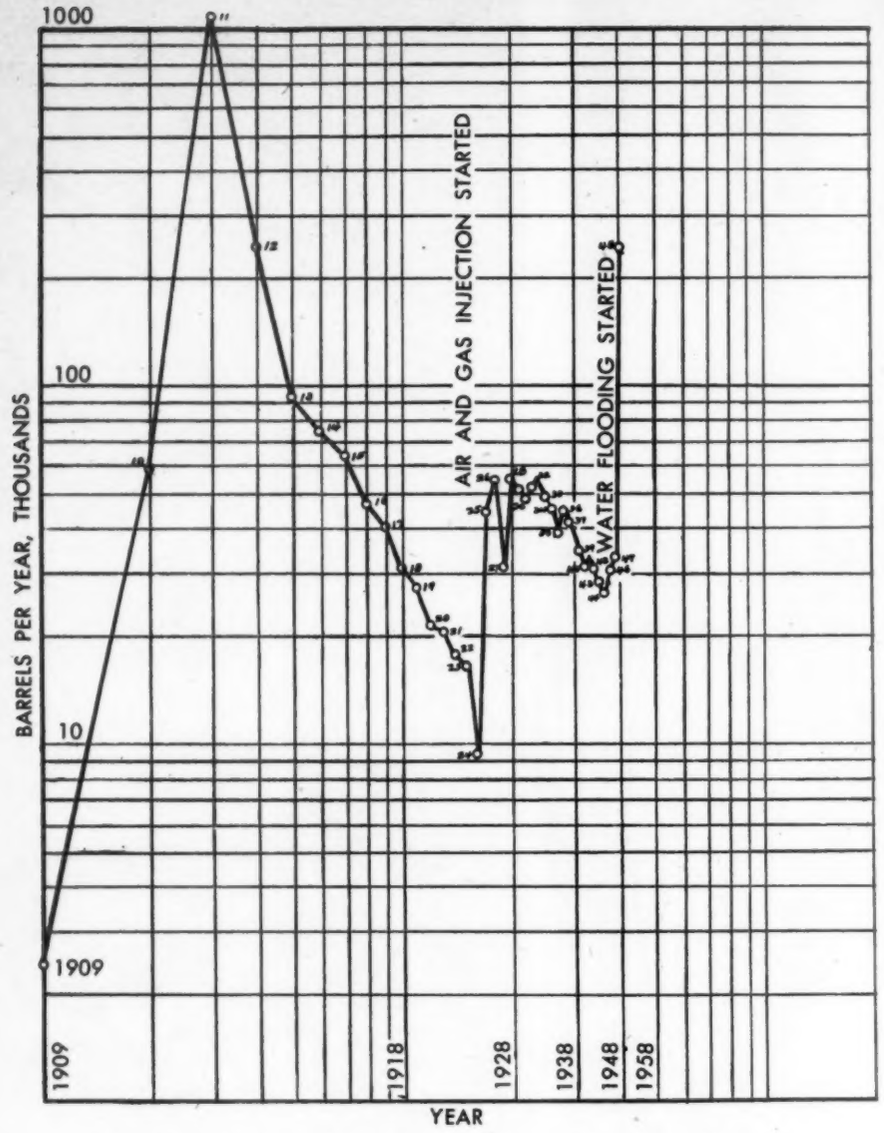


Production decline graph, Elliott pool, Nowata County, Oklahoma — Schermerhorn Oil Corporation.

Water Flood Recoveries

Tomorrow's increased recovery by artificial means may be aided by the study of natural water-drive operations today

S. FRED SHAW

Water-flooding performances are receiving increasing attention in view of the results that have been obtained during the past 10 years or more. Much interest in this subject has been stimulated by articles and papers that have been published in the technical magazines, in trade-journals, and in bulletins published by the U. S. Bureau of Mines. In this article there are summarized some of the more important projects in Oklahoma and Texas. Data have been compiled in the form of tables in order to provide comparisons between the various groups of fields where this method of recovery has been carried out. Comments also are made on natural water-drive operations.

EXCLUSIVE

PROBABLY the most important artificial water-flood project is that of the Bradford field, Pennsylvania, to which reference often has been made. Next in importance, perhaps, are the projects being carried out in the Nowata area, Oklahoma. In Table 1, there are compiled various projects of the Forest Oil Company,[1] which have produced 14,300,000 bbl by water-flooding to the end of 1949, from 6412 acres, amounting to a recovery of 2189 bbl per acre, or 81 bbl per acre-foot. Production decline graphs indicate that an ultimate water-flood recovery of nearly 2900 bbl per acre, or 106 bbl per acre-foot will be obtained from these projects. Primary recovery for the 21 projects of the Forest Oil Company is not available.

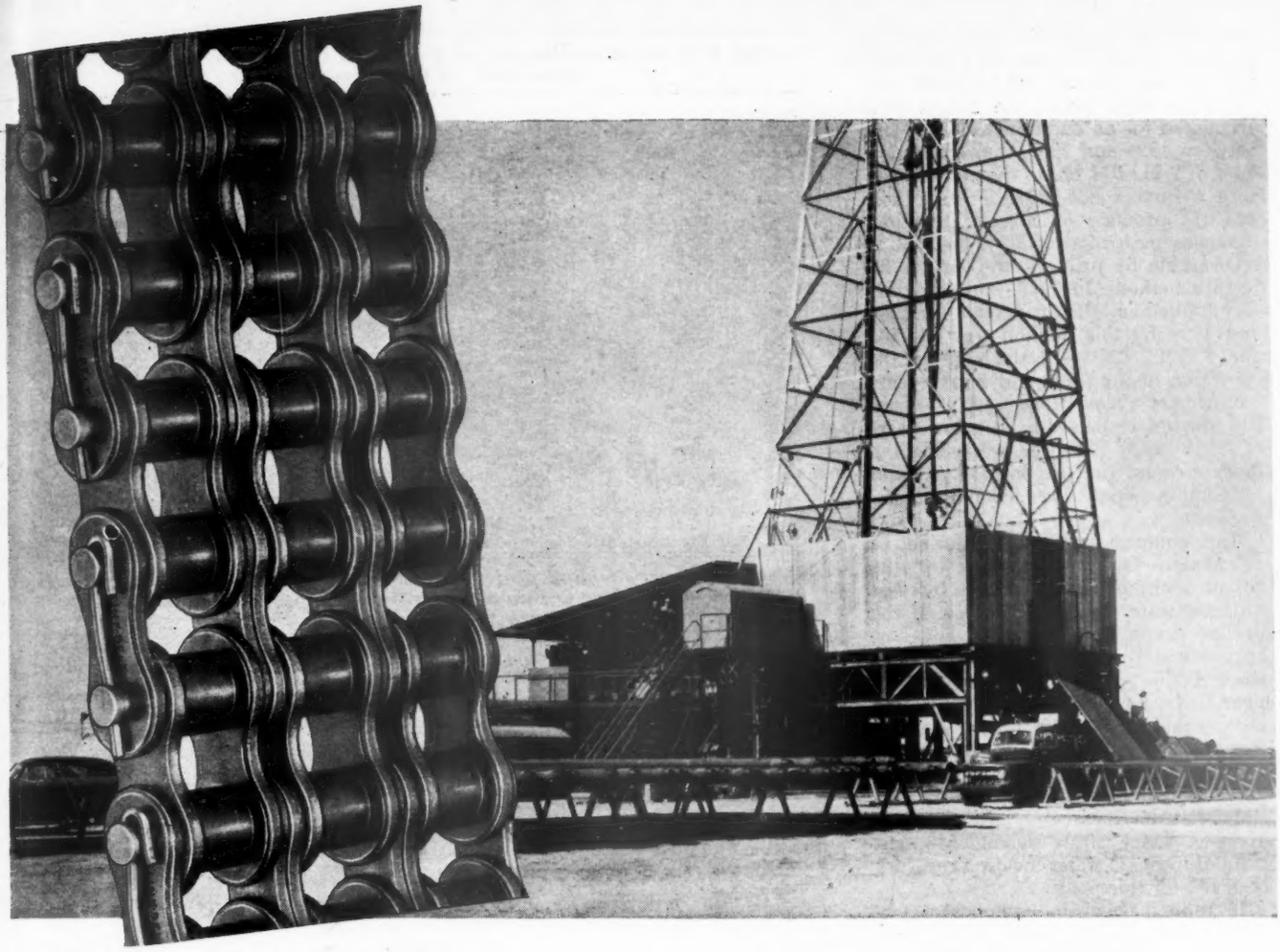
In Table 2 are listed data on 45 water-flood projects in the Nowata area[1] in which recovery by water-flooding to the end of 1949 has been 14,200,000 bbl of oil, or 2135 bbl per acre, or 67 bbl per acre-foot. Including the Forest Oil Company projects, this amounts to a water-flood recovery of 28,200,000 bbl to the end of 1949, or 73 bbl per acre-foot. Estimated ultimate water-flood recovery of these projects is 38,700,000 bbl of oil, or 2964 bbl per acre, or 100 bbl per acre-foot.

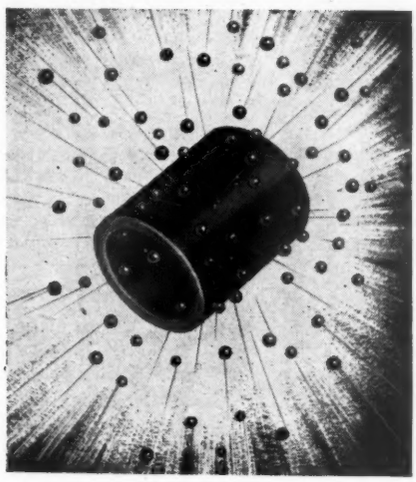
Data on primary recovery are difficult to obtain for many of the early operations in Oklahoma. In Table 3, primary recovery on 9 projects are indicated in the Nowata area,[1] subsequently converted to water-flooding, which had amounted to 5,500,000 bbl or 4446 bbl per acre, or 136 bbl per acre-foot, before being placed on water-flood. Inclusion of the Schermerhorn-Elliott pool air-gas injection recovery inflates primary recovery averages somewhat above actual primary recovery.

In districts of Oklahoma other than the Nowata area,[2] 38 projects on water-flood are tabulated in Table 4, where primary recovery to the beginning of water-flooding had amounted to 36,100,000 bbl of oil, or 136 bbl per acre-foot. To the end of 1949, water-flooding had produced an additional 4,300,000 bbl of oil, or 1064 bbl per acre, or 27 bbl per acre-foot. Ultimate water-flood recovery in these 38 fields is estimated at 7,600,000 bbl, or 2380 bbl per acre, or 64 bbl per acre-foot, which will be an increase of 47 per cent over that recovered during the primary recovery period. Several fields listed in Table 4 occur at depths such that it was not economically feasible to drill additional wells for the purpose of water-flooding. This may account to a considerable extent for the reduced water-flood recovery compared with that in the Nowata area.

Nowata Area

An outstanding performance of water-flooding is that of the Schermerhorn Oil Corporation-Elliott project in Nowata County, Oklahoma. This pool was discovered in 1909[1,3,4] and continued on primary methods until 1924 when air-gas injection was started with results shown graphically in Fig. 1. Primary recovery had yielded 1,799,293 bbl to the end of 1923, and an additional 114,000





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bbl probably could have been obtained by primary methods, making a total possible primary recovery of 1,913,000 bbl.

Air-gas injection in the Elliott pool accounted for an additional 900,748 bbl between 1924 and 1947, thus yielding a total of 2,711,011 bbl to the end of 1947 with a further 634,900 bbl being possible to produce by air-gas injection, thus making a total of 3,346,000 bbl as recoverable by primary and air-gas injection methods. In 1947, water-flooding was applied and the production for 1948 and 1949 by this method was 241,301 and 238,332 bbl respectively. With the exception of the third and fourth years on primary recovery at 1,038,840 and 246,000 bbl respectively, the two years of 1948 and 1949 on water-flooding methods were the two largest years of production since the field was discovered.

The comparatively short period of production on water-flooding in the Elliott pool makes it difficult to forecast ultimate water-flooding recovery. If the decline graph should remain, however, approximately parallel to that of the air-gas injection graph line, there would appear to be an additional 2,900,000 bbl recoverable for the 240 acres now under water-flooding. This would be an average of 14,100 bbl per acre, or 470 bbl per acre-foot, which seems hardly possible of achievement. Only after a period of some years can a dependable estimate of ultimate water-flooding recovery be made for this pool.

In Table 5 are given data on 24 water-flood projects in Texas[5,6] on which both primary and water-flood recovery have been published. Primary recovery from 2234 acres had amounted to 12,000,000 bbl of oil to the time when water-flooding was begun, which amounts to 5380 bbl per acre or 339 bbl per acre-foot. Artificial water-flood recovery to the end of 1947 had amounted to 927,000 bbl from these projects or 559 bbl per acre, or 34 bbl per acre-foot. Ultimate water-flood recovery from these 24 projects is estimated at about 1,550,000 bbl, which is 933 bbl per acre, or 57 bbl per acre-foot, or an increase of 17 per cent over that of primary methods. Possibly the higher acre-foot primary recovery of water-flood projects in Texas has left less oil for water-flooding recovery than has been the case in Oklahoma water-flood projects.

Active Natural Water-Drive Operations

Many early oil-field operations encountered water when on primary methods of production. In those years it was not so well recognized that an active water-drive could play an important part in flushing oil toward the wells. To the contrary it was considered a nuisance in that natural flow often ceased shortly after water entered the wells in any volume, and operating costs usually increased because of additional lifting expense and disposal of water. Very early examples of active natural water drive were Jennings, Louisiana, and Spindletop, Texas, both fields being discovered in 1901. About 20 years later there were further examples of active natural water-

TABLE 1. Water-flood projects of Forest Oil Corporation in the Nowata area, operations, to December 31, 1949.

Forest project number	Pool	County	Acres flooded	Thickness feet	Recovered by flood to 12/31/1949: Barrels	Barrels per acre	Barrels per acre-ft
1	Coody's Bluff	Nowata	157	40	1,096,440	6984	175
2	Alluwe	Nowata	710	25	1,047,532	1475	59
3	Alluwe	Nowata	217	35	210,069	968	28
4	Coody's Bluff	Nowata	168	30	565,934	3369	112
5	Coody's Bluff	Nowata	180	40	437,200	2301	58
6	Alluwe	Nowata	900	20	1,417,670	1575	79
7	Coody's Bluff	Nowata	1010	30	3,764,210	3727	124
8	Nowata-Claggett	Nowata	190	40	146,645	772	14
12	Coody's Bluff	Nowata	135	30	333,706	2472	82
14	Coody's Bluff	Nowata	555	40	1,396,434	2516	63
15	Chelsea	Rogers	330	25	958,171	2904	116
16	Alluwe	Nowata	610	35	1,265,546	2075	60
17	Chelsea	Rogers	130	30	169,340	1303	43
18	Alluwe	Nowata	40	20	51,209	1280	64
19	Alluwe	Nowata	170	30	53,311	314	10
20	Chelsea	Rogers	30	30	18,922	631	21
23	Alluwe	Nowata	100	25	157,540	1575	63
24	Chelsea	Rogers	150	28	228,161	1521	54
25	Alluwe	Nowata	340	25	353,928	1041	42
26	Coody's Bluff	Nowata	190	26	235,957	1242	48
27	Curl Creek	Nowata	100	30	130,871	1309	43
	Totals and averages		6412	27	14,038,796	2189	81
	Estimates ultimate water-flooding recovery		6412	27	18,323,550	2858	106

TABLE 2. Water-flooding projects in the Nowata area, Oklahoma, production recovered after beginning water-flooding to December 31, 1949.

Company	Project	Pool	County	Acres flooded	Thickness feet	Barrels recovered by flood to 12/31/1949: Total	Per acre	Per acre-ft
Albion Oil	Parker	Chelsea	Rogers	37	30	80,975	2189	73
Charles Aymer	Number 2	Coody's Bluff	Nowata	30	30	32,337	1078	27
Barr and Logan	Claggett	Nowata-Claggett	Nowata	458	40	524,593	1145	29
A. E. Bassinger	Coody's Bluff	Coody's Bluff	Nowata	935	40	2,796,329	2900	111
A. E. Bassinger	Curl Creek	Curl Creek	Nowata	350	25	891,905	2548	102
H. R. Coldren	Rogers-Johnson	Nowata-Claggett	Nowata	18	18	12,067	670	37
C. C. Harmon	Robinson-Orerman	Delaware-Childers	Nowata	170	50	917,560	5397	108
Harmon-Whitehill	Number 1	Coody's Bluff	Nowata	240	35	927,259	3864	110
Harmon and Whitehill	Number 2	Coody's Bluff	Nowata	430	40	986,399	2294	57
Harmon and Whitehill	Number 3	Chelsea	Rogers	130	25	233,780	1798	72
Harmon and Whitehill	Number 20	Talala	Rogers	40	25	25,500	638	26
L. L. Kroh	Pettit	Curl Creek	Nowata	15	25	64,496	3433	137
La Salle Petroleum	Keys	Alluwe	Nowata	120	23	132,970	1101	38
J. Lyytinen	Smith-Bryan	Curl Creek	Nowata	50	25	17,158	343	14
Max B. Miller	Slocter	Chelsea	Rogers	60	26	73,593	1227	53
R. Morrison	Beck	Delaware-Childers	Nowata	44	25	62,389	1418	56
Northern Oklahoma	Patton-Langley	Chelsea	Rogers	160	26	185,167	1157	45
Petroleum Engr's. Prod.	Alluwe	Alluwe	Nowata	255	55	761,951	2988	54
Phillips and Milam	Number 1	Nowata-Claggett	Nowata	280	32	565,833	2021	61
Phillips and Milam	Number 2	Chelsea	Nowata-Rogers	286	28	499,914	1748	62
Phillips Petroleum	Murray	Alluwe-Claggett	Nowata	85	30	75,132	884	29
R and T Syndicate	Riner	Delaware-Childers	Nowata	90	20	74,264	825	41
Reno Oil	Colpitt-White	N. Talala	Nowata	60	20	93,313	1555	76
Schermerhorn Oil	Elliott	Elliott	Nowata	240	30	492,486	2052	68
Shell Oil	Parris	Alluwe	Nowata	40	37	17,500	438	12
Shell Oil	Talala	Alluwe	Rogers	164	35	25,012	153	4
Sinclair O. and G.	West Security Fee	Delaware-Childers	Nowata	40	25	83,047	2076	52
Standard Parts	Graham	Chelsea	Rogers	45	20	105,836	2352	118
Standard Parts	Martin	Chelsea	Rogers	130	30	189,816	1460	47
Standard Parts	Numan	Chelsea	Rogers	55	25	110,724	2013	80
Thornton	Bradnor-King	Chelsea	Rogers	135	15	302,549	2241	150
H. J. Walter	Parker-Hill	Alluwe	Rogers	186	25	303,393	1631	65
H. J. Walter	Pumpkin-Center	Alluwe	Nowata	208	22	392,213	1881	86
Walter Bridgman	Pumpkin-Center	Alluwe	Nowata	128	30	246,021	1922	64
Wellsville Oil	Everett	Chelsea	Rogers	208	20	628,576	3112	155
Wellsville Oil	Projects 2 and 4	Chelsea	Rogers	44	12	64,800	563	45
Wellsville Oil	Project 3	Chelsea	Rogers	36	12	32,838	912	76
L. D. and P. White	Mouse-Claggett	Nowata-Claggett	Nowata	30	25	54,211	1807	72
Whitehill Oil	Alluwe Group	Coody's Bluff	Nowata	120	25	84,114	701	28
Whitehill Oil	Armstrong	Alluwe	Nowata	50	25	67,471	1499	60
Whitehill Oil	Bishop-Levine	Coody's Bluff	Nowata	70	25	70,542	1008	25
Whitehill Oil	French	Alluwe	Nowata	80	25	125,831	1573	63
Whitehill Oil	Hall	Chelsea	Rogers	97	30	207,536	2149	71
Whitehill Oil	Woods-Manus	Alluwe	Nowata	80	30	99,690	1246	41
Wiley and Roberts	Parish	Alluwe	Nowata	130	30	466,499	3588	120
Totals and averages				6,653	32	14,205,589	2135	67
Forest projects, from Table 1				6,412	27	14,038,796	2189	81
Combined total Nowata area				13,065	29.5	28,244,385	2162	73
Estimated ultimate recovery to be obtained by water-flooding, 66 projects				13,065	29.5	38,724,508	2964	100

TABLE 3. Fields in the Nowata area for which data on primary recovery are available.

Operator	Field	Project	Acres	Thickness, feet	Bbl of oil produced	Bbl per acre	Bbl per acre-ft
C. C. Harmon	Delaware-Childers	Project 1	283	50	1,535,822	5427	108
King Development	Curl Creek	Terry	5	22	2,168	494	22
L. L. Kroh	Curl Creek	Petit	100	25	343,321	3433	137
Reno Oil	Colpitt-White	North Talala	60	20	116,406	1940	97
Schermerhorn	Elliott	Elliott	543	30	2,711,062[1]	5020	167
Shell Oil	Alluwe	Parris	40	37	17,434	436	12
Sinclair Oil and Gas	Delaware-Childers	West Security	109	25	558,261	5122	204
Wellsville Oil	Chelsea Rogers County	Martin	60	18	173,791	2897	156
Whitehill Oil	Delaware-Childers	Martin-Poorboy	32	26	54,465	1702	66
Totals and averages			1231	32.8	5,494,730	4446	136

[1] Includes both primary production and production on air-gas injection; that is, all production before water-flooding.

TABLE 4. Water-flood projects in Oklahoma, other than Nowata area, for which primary recovery is known.

Company	Project	Pool	County	Primary recovery					Water-flood recovery to 12/31/1949				
						Barrels of oil				Barrels of oil			
				Acres	Thickness feet	Total	Per acre	Per acre-ft	Acres	Total	Per acre	Per acre-ft	Remarks
Amerada Petroleum..	Stillwater	Stillwater	Payne	40	10	261,106	6,527	653	40	97,834	2446	245	Aban. 9/44
Amerada Petroleum..	J. Lewis	Stroud	Creek	73	100	1,914,487	26,267	263	73	390,683	5352	54	
Barnsdall Oil.....	Osage No. 4	Osage	Osage	55	15	143,043	2,601	160	34	32,847	966	64	Aban. 3/44
Bird Creek Oil.....	Blackwood	Bird Creek	Tulsa	110	50	620,219	5,638	113	110	7,721	70	1	
Blackwell Oil and Gas	Beulah Tucker	S. Hickory	Osage	100	50	226,205	2,262	45	100	2 879	29	½	Aban. 4/48
Bruce Oil.....	Weber	Weber	Washington	112	15	552,633	4,934	329	112	3,841	110	7	
Ralph Bynum.....	Sable	Hickory Creek	Osage	30	55	71,586	2,386	43	30	5,696	190	4	
Continental Oil Ref...	Stewart	Buck Creek	Osage	50	25	169,330	3,387	136	50	9,672	193	4	
Cooperative Ref.....	Hicks	Bartlesville-Dewey	Washington	220	20	1,254,141	5,700	285	220	47,121	214	11	
Forest Oil.....	Osage	Hickory Creek	Osage	100	30	183,634	1,836	61	100	68,699	687	23	
Forest Oil.....	Project 28	Weber	Washington	575	28	3,561,650	6,194	221	17	7,126	420	15	
Gled Oil.....	Koch	Mannford	Creek	100	40	255,275	2,553	64	100	99,538	995	25	Aban. 4/46
S. K. Goodman.....	G. Fencer	Bartlesville-Dewey	Washington	100	35	168,075	1,680	48	40	11,586	290	8	
Gulf Oil.....	K. Bear	Deep Fork	Creek	50	50	134,177	2,677	53	50	31,998	640	13	
Gulf Oil.....	Payne	Turley	Tulsa	45	100	358,020	7,956	80	45	35,370	786	8	Aban. 1939
Gulf Oil.....	Shawrer	Tonkawa	Noble	160	60	674,878	4,218	70	30	17,562	583	10	Aban. 7/39
Gulf Oil.....	E. Spocogee	Glenn	Creek	40	46	240,194	6,004	130	40	7,888	197	4	
Harmon and Whitehill	Larney	Okmulgee	Okmulgee	67	50	407,750	6,086	122	67	6,163	92	2	
Hill and Hill.....	Allen	Allen	Pontotoc	320	12	366,101	1,144	95	100	17,251	173	14	
Indian Ty. Il. Oil.....	Osage	Pershing	Osage	110	30	352,000	3,200	107	70	12,742	182	6	Aban. 8/39
Keener Oil and Gas...	Bartles-Fee-Shailer	Weber	Washington	80	28	503,600	6,295	225	80	36,310	454	16	
Magnolia Petroleum..	L. Street	Olive	Creek	166	30	212,352	1,327	44	160	4,011	25	1	Inactive 11/47
Mid-Continent Pet....	Hallett	Jennings	Pawnee	400	25	664,090	1,660	66	400	47,541	119	5	
Mid-Continent Pet....	Hampton	Olympic	Hughes	80	62	643,159	8,039	130	130	20,730	2073	34	
Mid-Continent Pet....	K. Bear	Deep Fork	Creek	80	50	205,000	2,563	51	80	47,579	595	12	
Mid-Continent Pet....	Morris	Morris	Okmulgee	234	30	1,516,929	6,483	216	60	8,460	141	5	
Mid-Continent Pet....	North Hill	Cushing	Creek	160	40	469,137	2,932	73	60	53,140	886	22	
Mid-Continent Pet....	School land No. 66	Yale-Quay	Pawnee	420	60	6,565,797	15,633	261	420	2,749,856	6547	109	
Ross Oil.....	J. H. Hadley	Hickory Creek	Osage	200	30	232,555	1,163	39	200	127,713	639	21	
Sinclair Oil and Gas...	Covington	Garber	Garfield	660	19	3,703,956	5,612	195	40	45,327	1133	60	
Sinclair Oil and Gas...	Dunson	Cushing	Creek	160	80	1,704,136	10,651	133	60	1,881	31	0.4	
Skelly Oil.....	Duncan	Wynona	Osage	160	100	738,236	4,614	46	160	24,473	153	1.5	
Sunray Oil.....	Project 1	Barnsdall	Osage	130	32	171,653	1,320	41	130	3,500	27	1	Aban.
Wilcox Oil.....	Sac and Fox	Sac and Fox	Lincoln	970	80	2,946,413	3,038	38	62	73,774	1190	15	
Winona Oil.....	Bern	Fish	Hughes	230	28	1,150,000	5,000	180	230	1,526	7	0.3	
Winona Oil.....	Project 2	Birch Creek	Osage	220	16	224,345	1,020	64	140	103,209	737	46	
Winona Oil.....	Project 1	Buck Creek	Osage	285	25	420,647	1,107	44	285	58,918	207	8	
Wood Oil.....	Scott and McAdoo	Okmulgee	Okmulgee	60	21	37,308	622	21	60	3,360	56	2	
Totals and averages.....				7152	41.4	36,103,817	5,635	136	4065	4,325,523	1064	27	
Estimated ultimate water-flood recovery.....				*3256	37	.....	.....	...	....	7,638,000	2380	64	

* Acreage under water-flood does not cover as much area as that of primary operation.

TABLE 5. Water-flood projects in Texas, for which primary recovery is known.

Company	Project	Pool	County	Primary recovery					Water-flood recovery to 12/31/1949				
						Barrels of oil				Barrels of oil			
				Acres	Thickness feet	Total	Per acre	Per acre-ft	Acres	Total	Per acre	Per acre-ft	Remarks
Bridwell Oil.....	Mercer-Hausler	Olney	Young	38	20	586,280	8,375	478	38	3,015	80	4	Aban.
Cable Oil.....	J. S. Webb	Webb	Archer	31	12	113,337	3,656	305	18	87,745	4930	411	
Cable Oil.....	Willis	.....	Wichita	130	11	245,586	2,143	107	130	47,808	352	18	
Cable Oil.....	Prideaux "M"	Prideaux	Young	15	7.5	2,679	179	24	15	5,074	338	45	
Cable Oil.....	G. Williams	Prideaux	Young	20	9	158,000	7,900	878	20	15,129	756	84	
Cable Oil.....	J. Williams	.....	Young	38	13	60,952	1,604	123	38	90,818	2390	184	
Dean Bros.....	J. T. Davis	Isenhower	Callahan	60	15.4	398,318	6,630	430	120	6,630	55	6	
Dean Bros.....	Rutherford-Davis	Isenhower	Callahan	129	15.5	443,281	3,436	222	172	62,002	360	23	
Dean Bros.....	Pratt	Pratt	Stephens	30	40	369,830	12,330	308	30	2,833	94	3	
Fain-McGaha.....	Lewis-Steffens	Lewis-Steffens	Jones	350	20	1,359,608	3,885	194	350	83,135	2375	119	
Humble Oil and Ref...	Stephens	South Vernon	Wilbarger	120	22	1,928,573	16,064	730	18	34,983	1943	88	
H-Y Oil.....	Larimore	Larimore	Young	20	15	135,878	6,800	453	20	6,018	301	20	
Magnolia Petroleum..	Goins	Burkburnett	Wichita	160	12.6	630,000	3,940	313	160	50,717	317	25	
Martin-Kurtz.....	Sewell	Sewell	Jack	60	35	36,569	610	35	60	23,523	392	22	
Producers Dev.....	Thomas	Thomas	Archer	95	15	746,380	7,857	522	20	62,302	3115	208	
Reno Oil.....	Oldham	Oldham	Archer	117	16	1,071,573	9,150	572	65	12,321	190	8	
Reno Oil.....	Benson-Campbell	Campbell	Young	128	20	531,944	4,150	208	90	67,770	752	38	
Roark and Hooker....	Daughtry	Lewis-Steffens	Jones	38	15	195,776	5,200	357	38	668	18	1	
Roeser and Pendleton	Frye	Frye	Shackelford	73	11	260,263	3,600	327	100	5,980	59	5	
Shell Oil.....	Ferguson	.....	Archer	66	10	183,917	2,787	279	30	93,941	3131	313	
Street Inv.....	Trent	Noodle Creek	Jones	433	9	2,251,788	5,200	578	51	17,452	342	38	
Trumpter Petroleum..	Slaughter	.....	Callahan	14	10	37,597	2,685	266	7	5,199	743	74	
White and Duncan...	Webb	Webb	Archer	32	8	65,000	2,030	254	32	109,012	3407	426	
White and Duncan...	Smith-Wolfe	.....	Young	37	15	202,190	5,460	364	37	33,320	900	60	
Totals and averages.....				2234	15.9	12,015,319	5,380	339	1659	927,395	559	34	
Estimated ultimate water-flood recovery.....				1659	16.3	.....	.....	...	1659	1,548,400	933	57	

drive at Bellevue, Louisiana (1921), Luling, Texas (1922) Saxet, Texas (1922), Powell, Texas (1923), and Wortham, Texas (1924). All these fields began to produce large quantities of water only a few years after the fields were discovered. Shortly afterward there followed the examples of Tullos-Urania, Louisiana (1925), Hendrick, Texas (1926), and Darst Creek, Texas (1928), where large quantities of water have been produced and where the recovery of oil has been high. These fields are still producing large quantities of water with important volumes of oil.

In 1930 the East Texas field, the largest of all fields in the United States, was discovered. It was not long before water began to encroach, and under the severely restricted production practices in force in this field, the water now amounts to more than 50 per cent of the total volume of fluid produced. Some years later, fields were discovered in Texas at Corpus Christi (1935), Placedo (1935), Midway (1937), and Minnie Bock (1939) where large volumes of water have made way into the fields. These fields are producing important quantities of oil with a rather gentle decline in annual production, and it appears that very high acre-foot recoveries will have been made. Some wells in the Placedo field have shown remarkable recoveries, apparently up to 90 per cent or more of the oil that seems reasonable to have existed in the reservoir when the wells initially were completed.

Other fields along the Gulf Coast may be mentioned as having had considerable active water encroachment such as Barber's Hill, Bosco, Goose Creek, Humble, Iowa, and Roanoke. This is far from completing the list of fields where active natural water-drive has played an important part in flushing oil into the producing wells.

The East Texas field (1930) is an example of high recovery that will result from active natural water-flood, and estimates would seem to indicate that as much as 1000 bbl of oil per acre-foot may be expected. Powell and Wortham have yielded about 1000 bbl

per acre-foot, and these fields, too, were affected by an active water-drive. Such recoveries are unusually high, and it could easily appear that it is due, at least partly, to the movement of water in pushing and scouring the oil from the sand, and in moving it to the wells.

Midway, Minnie Bock, and Placedo fields of Texas are notable examples of an active water-drive in moving the oil to the well bore. Advantage has been taken of this condition on various leases in lifting all the fluid that known production methods are capable of handling, and in economically producing oil percentages below 1 per cent of the total fluid lifted.

Working conditions may interfere with carrying this method of production operations to the maximum point of recovery. Even though rapid withdrawals may in certain instances yield higher ultimate recovery, production must conform to market demand, whatever may be the effect on production efficiency.

On certain leases in the Placedo field[7] every effort was made to produce the oil allowables even though it necessitated the lifting of large quantities of water until the volume of liquid lifted became so great that it was uneconomical to produce the oil. At this point, wells have reached a point of oil production as low as 0.75 per cent of the volume of liquid produced, and volumes of liquid reached 5000 to 6000 bbl per well per day.

Economics in such instances as those described are dependent upon low cost of lifting the fluid, and low cost of water disposal. A further consideration not yet clearly worked out is that of opening the drainage area surrounding the well so that large volumes of liquid can enter the well-bore without creating an excessive draw-down in pressure below that of the reservoir pressure. This subject has been discussed for many years[8,9] and so far as loose sand reservoirs are concerned there has not been a great deal of success in bringing about this condition. Acidizing wells in limestone reservoirs, however, has been very beneficial in many instances. The use of the hydrafrac process has been helpful in other instances, but the treatment of the soft unconsolidated sands of the recent geologic periods found along the Gulf Coast for the purpose mentioned has been very uncertain in its application. Production from various wells in these soft sands has been unsuccessful in an attempt to bring about this special condition.

The writer has seen exceptionally beneficial results accomplished in these loose sand wells by careful handling of production over a considerable period of time, that is extending over a period of years rather than days or months, in setting up an increased permeable condition around the well. But no safe rule can be stated to cover the many conditions that prevail. Suffice it to say that there must be employed a dependable method of production that can handle large volumes of liquid under a steady rate of flow to prevent disaster.

Natural Water-Drive Aided By External Injection of Water

There is a growing belief in fields having a moderate degree of water-drive that results can be improved by injecting water at the edges of the pool in the early stages of production to augment the natural water supply. Experience will determine in the course of time whether this method can be so controlled at a cost that is not excessive, in order that a considerable increase in recovery percentage can be brought about over that which would be obtained without such procedure. In some fields, such as Midway, Arkansas[10], and West Tepetate, Louisiana[11], water injection was begun early in order to supplement the water found along the outer edge of the field for driving oil to the wells, and it is possible that these experiences will lead into methods whereby lifting methods capable of large daily production of water can be employed to scour the sand of all but minute vestiges of oil. It is predicted at Midway[10] that recovery by this method will yield 540 bbl per acre-foot or 45 per cent of the oil originally existing in the reservoir. It seems to the writer that there should be a higher recovery than 45 per cent in this field where porosity is on the order of 26 per cent if the method works out with a good degree of success. Recovery from No. 1 reservoir at West Tepetate with porosity of about 32 per cent is predicted at 14,600,000 bbl, or 679 bbl per acre foot, or a recovery percentage of about 60 per cent of the initial oil in the reservoir. This recovery also may be exceeded if unforeseen conditions in the reservoir, or of economics, do not arise to prevent a high degree of scouring of the oil from the sand.

It is quite possible that the mechanics of the influence of water in increasing recovery of oil from the reservoir is not as well understood as will become the case during the next few years after experiences have been correlated in those fields where active water-drives are under way. One likes to think of an oil-water interface, and this concept would be a beautiful one if the movement of water could be so controlled within economical limits of time that a clear-cut oil-water flood line could be established and made to persist as such. It seems that experiences in many, perhaps in most fields the actual conditions do not

Oil Recovery Rate High

In the early days of oil production, recovery of 25 to 30 per cent of the oil in a field was considered satisfactory. Today, with improved conservation practices, oil men are recovering up to 60 to 70 per cent and even higher of the oil in the producing horizon in some fields. When one considers that the porosity of the oil sand is like a rock, and that oil is produced through an 8-in. hole from under some 20 acres of land, 70 per cent recovery is real engineering achievement.

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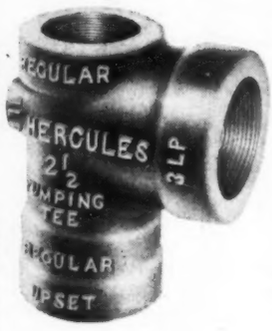

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conform to this concept, except in the very early stages of water-drive. It does not seem reasonable to suppose that as high recoveries would be the result of such an operation as would be the case where the flushing action is such as to scour the sand of its oil contents. This is more likely to be accomplished if a velocity as high as possible is set up and is practicable to be brought about.

Support for the use of higher velocities was found in the experiments on a laboratory scale carried out by Frank G. Miller of the U. S. Bureau of Mines during or before 1941.[12] In this report reference is made to other studies along this line. Experiences of the writer would tend to point toward an even higher recovery of oil than indicated by the experiments described in the report, where velocities in actual practice in certain oil fields were of a higher order than those employed in these laboratory experiments.

On the other hand, earlier laboratory experiments by Uren and students[13] reached opposite conclusions from those of Miller. This brings out the thought that laboratory tests on a comparatively small scale cannot simulate field results, and confirmation is needed from actual field results before any definite and safe conclusions can be drawn.

At any rate it seems probable that experiences obtained in the course of time from application of active natural water-drive conditions may serve to aid in working out better practices in artificial water-flooding projects so that higher recoveries may be obtained than those indicated in the tables in this article in various fields of Oklahoma and Texas.

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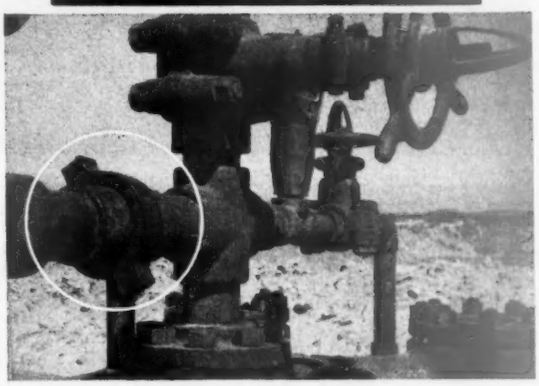

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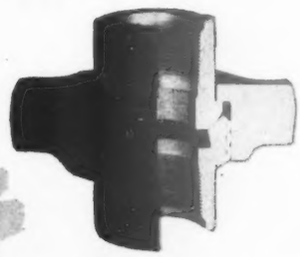

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FIG. 1. Example of inside seam (overlap) defect in drill pipe tested.

FIG. 2. Another variety of inside seam defect.

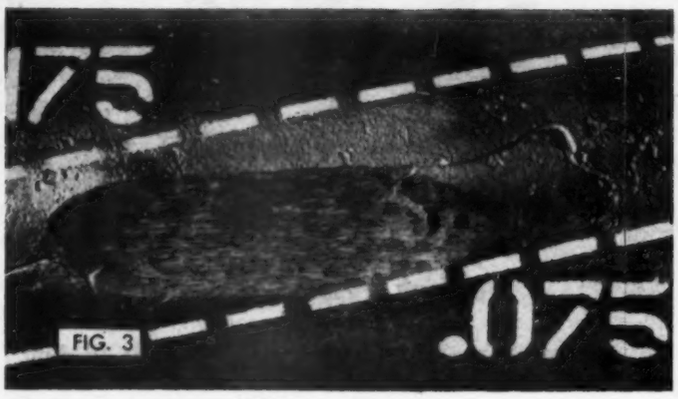

FIG. 3. Outside seam. Upper numerals designate tube number and lower ones indicate defect depth.

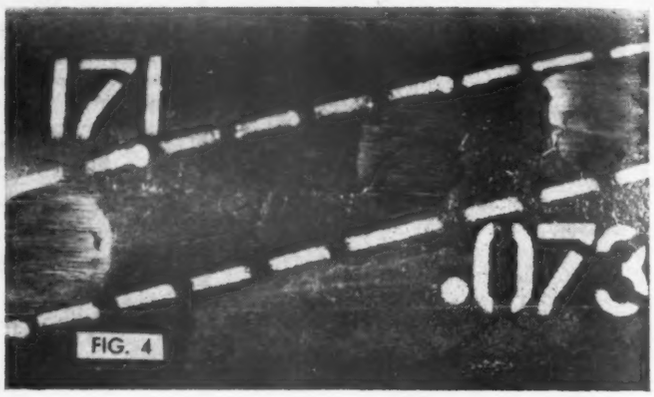

FIG. 4. Outside seam. Grinding marks were made to find depth of defect.

Drill Pipe Rejects Show Good Service Life

H. G. TEXTER†

An API paper entitled "Field Test On Rejected Drill Pipe" presented by A. W. Thompson of Thompson-Carr, Inc., and the writer in 1948 discussed a test made to learn whether the usual types of mill defects had any appreciable effect on the service life of drill pipe. The test was conducted with 183 lengths (5300 ft) of 4½ in. OD untreated pipe, all of which had been rejected at a pipe mill for various defects, principally outside and inside seams and pits. All of the defects were of a nature heretofore considered as making the pipe utterly unfit for field service.

The experiments were conducted by Thompson-Carr, Inc., in the West Texas fields where corrosive salt water conditions greatly aggravated the frequency of drill pipe failures. In fact, they were once so frequent that contractors felt very certain the pipe must in some way be at fault. The test string was used to drill twenty "salt string" holes 11 and 12½ in. to an average depth of 2323 ft, during which 21 failures occurred. They were either complete fractures resulting in fishing jobs, or washed out cracks that were caught before they parted.

Examination of each failure showed that not one had occurred in a mill defect. *All of them resulted from corrosion fatigue.* Thus, it seemed fairly well established that the ordinary, visible types of mill defects had no appreciable effect on the incidence of field failures. But we did conclude, however, that "There must, of course, be some limit as to the depth or shape or direction of mill defects beyond which we dare not go." Also a discusser of the paper pointed out the fact that because corrosion was such a large factor, the time element may have been too short for the defects to exert their normal effect. Others expressed the feeling that we hastened the occurrence of corrosion fatigue failures, because Thompson had deliberately used a minimum of drill collars so as to increase the magnitude of the bending stresses and, therefore, hastened mechanical failure.

Thus, we concluded that the problem deserved further study, particularly to learn just what sort or what depth of defects really would result in failures. For the purpose we made up two new strings of mill defects, one of which was accepted by Thompson-Carr and the other by Stanolind Oil and Gas Company. If anything, the defects in these strings were greater than those in the previous test: Many of them were so

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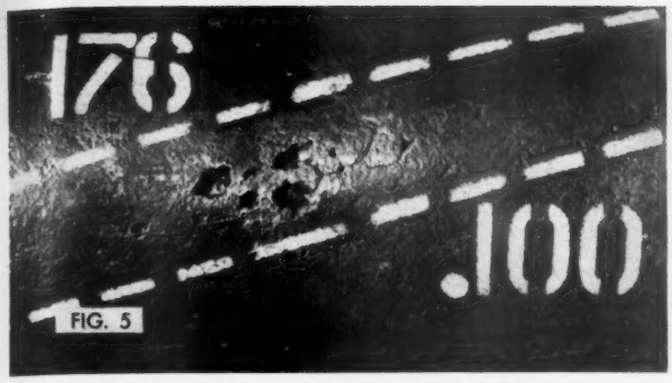

FIG. 5. Outside pits. Deepest pit here is over twice the API allowance. This defect did not fail in service.

FIG. 6. Outside pits. Deepest pit is almost three times the API allowance. Defect did not fail in service.

deep and so "horrible" looking that the plant superintendent almost refused to let them be shipped. As before, we used 4½ in. OD by 16.60 lb, Range 2, mixed Grades D and E, just as they were discarded by the mill inspectors. Each length, however, was tested to 5000 psi internal water pressure; the only procedure differing from the treatment of regular drill pipe tool joint product.

Before shipment, a great many photographs were taken of so-called typical injurious defects. Good photographs of inside defects are hard to obtain, so none were made of lengths used in the test. For illustration, however, several tubes were cut open to photograph typical cases of bad inside seams (often called overlaps), Figs. 1 and 2. Many of those actually run were even worse as indicated by two that failed in Figs. 10 and 11.

Figs. 3 and 4 illustrate types of outside seams in some of the lengths shipped. The upper painted numerals are the tube numbers and the lower ones denote the defect depth. The seams were ground to find their true depth. API drill pipe is discarded if the depth is more than 0.042 in. (12½ per cent of 0.337 in., nominal wall thickness of 4½ in., 16.60 lb drill pipe). Typical outside pits are shown in Figs. 5 and 6. In tube No. 176 the depth of the deepest pit is over twice the API allowable and that in tube No. 174 is almost three times the allowable. It is interesting to note that neither 174 or 176 failed in service.

In an effort to disprove that rate of failure has any tendency to nullify the effect of mill defects we took such preparatory steps as: (1) Shot peening and plastic coating most of the lengths (2) Using adequate drill collar weight during drilling to keep the pipe in tension. Furthermore, these steps reduced the very real financial hazard incurred in operating drill pipe strings, every length of which contained defects that no mill or outside inspector would ever consider passing, and which no driller or toolpusher could even hear about without a shudder. Every length was properly identified and its defects located and catalogued before drilling started.

The lot of mill rejects destined for Thompson-Carr consisted of 84 lengths (2500 ft). By chance, 54 happened to be Grade D and 30 Grade E. To study the relative resistance to corrosion fatigue, 41 lengths were internally shot blasted and shot peened, and 43 were shot blasted and coated with a phenol-formaldehyde thermal setting plastic. The string drilled in 24 wells, a total footage of 66,634 with total rotating hours of 3071. All of this was in the Permian Basin of Texas and New Mexico, where corrosion fatigue is very prevalent.

The holes drilled were the "salt string" holes, mostly 11 and 12¼ in. for setting 8⅝ and 9⅝-in. OD casing. They ranged from 519 to 3860 ft deep, the deeper wells requiring additional lengths of non-defective drill pipe. Dur-

FIG. 7. Left, failure assumed to be caused by notch fatigue induced or aggravated by slip marks. No mill defects were at the failure.

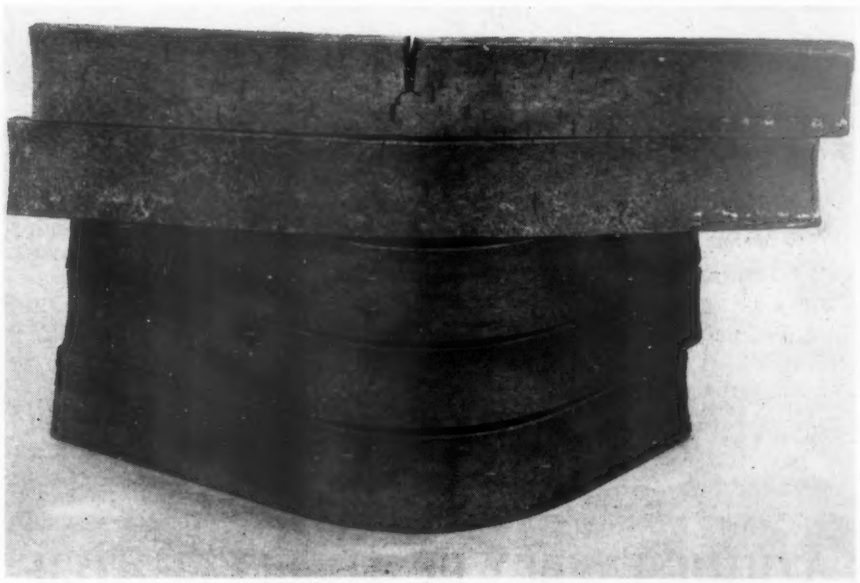

FIG. 8. Corrosion fatigue is indicated by cracks in the two upper bend-test specimens.

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FIG. 9. Washed out crack failure caused by corrosion fatigue. Internal seam defect had no connection with failure. Arrows indicate additional cracks.

FIG. 10. First failure definitely originating in a mill defect. Tube contained an extremely scabby internal seam running its full length.

FIG. 11. Another failure induced by a mill defect. Similar to Fig. 10, the tube contained a bad inside seam.

ing this period fourteen failures occurred, either washed out cracks or complete failures, eight of which were returned to the mill for study. Of the total, 11 were in Grade D pipe and three in Grade E, which may or may not be of significance. Only two failures (not corrosion fatigue) were in plastic coated pipe, and 12 were in shot blasted and shot peened pipe. This also may be significant as only one corrosion fatigue failure occurred in uncoated pipe. Six of the failed lengths were apparently cut up or otherwise discarded before they could be analyzed.

First failure in the Thompson-Carr string occurred at 20,570 ft of hole (1169 rotating hours), the second occurred about the same time, and the third at 31,200 ft. All three occurred about 2½ ft from the box, which puts them in the slip area. As it was known that mill defects were not at fault, and as there was no evidence of corrosion fatigue, it may be inferred that the failures were due to notch fatigue induced by, or aggravated by, slip marks. Fig. 7, a view of the first failure, is illustrative of the first three.

The test for corrosion fatigue, incidentally, is to cut strips from the pipe, Fig. 8, and bend them backward in a vise so that elongated inside surface may be examined. If unattacked the surface will be unbroken, as in the lower three specimens. Even a slight amount of corrosion fatigue causes from a few to very numerous transverse cracks, as in the upper two backward bend tests.

Fig. 9 is a typical example of a failure, a washed out crack, due specifically to corrosion fatigue. This was tube No. 251, Grade E, which failed after drilling 51,360 ft of hole (2431 rotating hours). Its mill defect was an internal seam running from the box end upset for a distance of 12 ft. The failure occurred at 16 ft 8 in. from the box and therefore had no connection with the defect. The tube had been shot blasted and shot peened, but was *not* internally coated. Arrows in the photograph indicate additional cracks on the inside surface.

Fig. 10 is a photograph of the first failure which definitely originated in a mill defect. This was tube No. 209, Grade D, shot blasted and shot peened only, in which there was a very bad internal seam running the full length. It is an example of one of the tubes that was shipped *only* because we wanted to in-

FIG. 9.

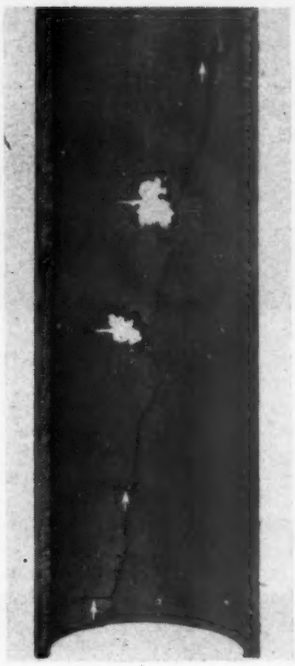

FIG. 10.

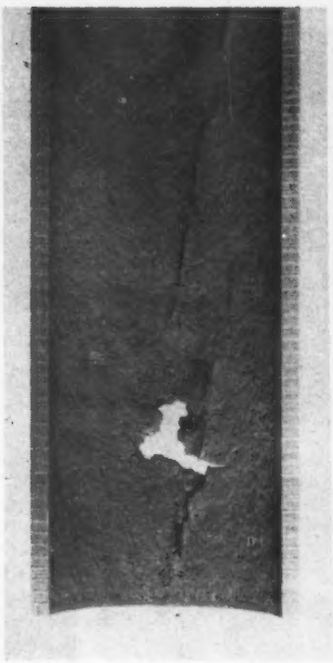

FIG. 11.

clude a defect that would very likely cause failure. *It did.*

This seam was of the very scabby type, the thin edge of which curled up into the inside of a tube to such an extent that it would not have passed a drift plug. (Drifting, however, is not required by the API specifications for the body of drill pipe.) It could be seen by a very casual glance into the inside and would never be passed by anyone short of a blind man.

Apparently corrosion of the very thin outer edge, sticking up into the mud flow, had induced transverse cracks which, in two places, progressed through the wall of the pipe and were then washed into rounded holes by escaping mud. This, then, is a type of mill defect that very definitely can result in field failure, at least in corrosive mud areas. It is the writer's firm opinion, slightly prejudiced possibly, that the defect would not have resulted in failure in non-corrosive territory.

It is of interest that this first failure in a defect did not occur until the string had drilled some 50,000 ft of hole. As the whole string was retired at 66,634 ft the defect, in spite of being extreme, reduced the life of the tube only 25 per cent.

Fig. 11 illustrates the only other example in the Thompson-Carr string, of a failure induced by a mill defect. It is quite similar to the tube in Fig. 10 as to type of defect and mode of failure. This was tube No. 225, Grade D, shot blasted and shot peened. It failed in the twenty-fourth or very last well, just before the string was discarded, and is therefore credited with 66,634 ft of hole (3071 hr). It appears that most of the paper thin edge of the upturned seam had corroded away and the tube had almost escaped developing a crack entirely through the wall. If so, this would account for there not having been literally dozens of failures of this type, as both the Thompson-Carr and the Stanolind strings contained more rejectable inside seams than any other type of defect.

The Stanolind string consisted of 200 lengths (5800 ft). There were 64 lengths of Grade D and 136 of Grade E. Sixty of the lengths contained the original mill scale, 75 were shot blasted and shot peened, and 59 were shot blasted and plastic coated. The string drilled in seven Andrews and Ector County, Texas wells. Instead of drilling salt string holes, it drilled 8¾ in. holes below the surface casing for setting the production string, mostly 7-in. OD casing.

Approximately 3800 ft of hole was made in each of the 7 wells, or an actual total for the string of 25,192 ft, at which time it was discarded. As the Stanolind string drilled only the very much harder, lower formations, as compared with the softer, upper formations penetrated by the Thompson-Carr string, in the same general area, there can be no comparison whatsoever as to the relative service of the two strings. Had Stanolind kept a record of rotating hours, as did Thompson-Carr, it is probable that the strings would have shown approximately equal service.

As the wells were deeper (up to 8600

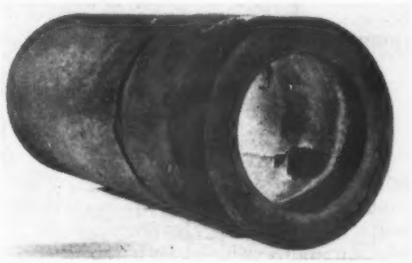

FIG. 12. Transverse crack failure, apparently the result of pure fatigue, has its center 180 degrees from the tube defect, a bad inside seam. The defect, therefore, did not effect the failure.

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FIG. 13

FIG. 14

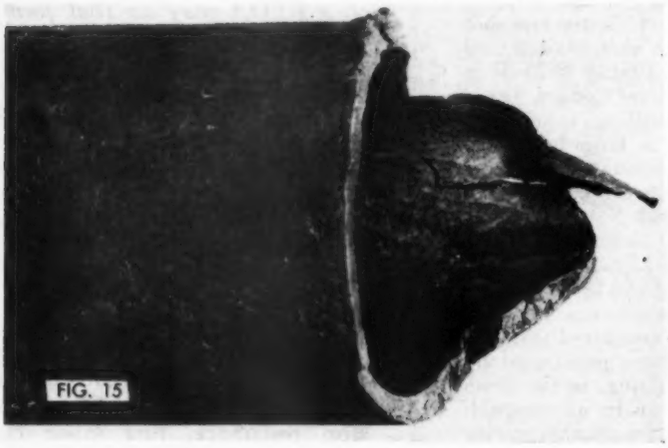

FIG. 15

FIG. 13. Defect here was a short inside seam, but the failure occurred two feet away in a crack originating on the outside.

FIG. 14. This tube burst at an inside seam under 2000 psi mud pressure while trying to burst a circulating sub.

FIG. 15. A deep intermittent inside seam the entire length of tube did not cause this failure. It started in transverse scars shown in the foreground.

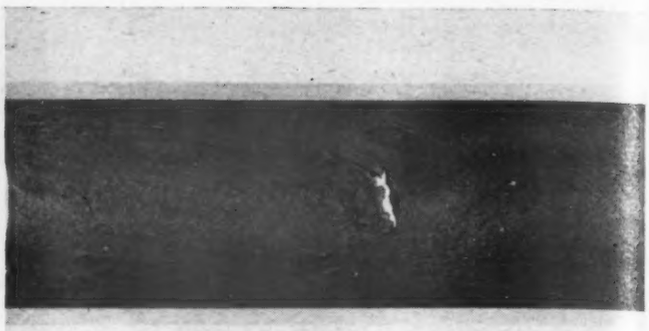

FIG. 16

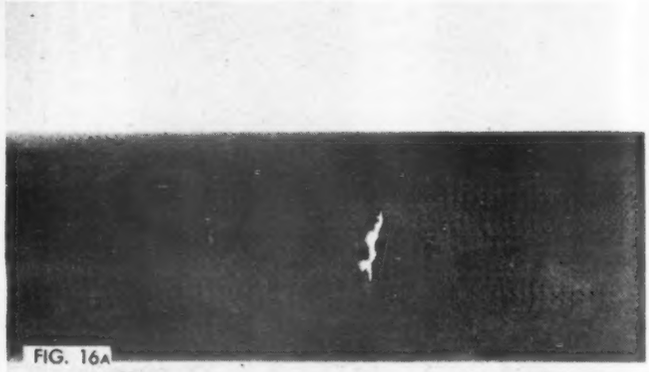

FIG. 16A

FIG. 17

FIG. 16. Although there is a sliver near the crack and some roughness beneath it, evidence shows this failure may have started from an external crack caused by spider-slip marks, Fig. 16A.

FIG. 16A. Spider slip marks are a common cause of notch fatigue failures and this appears to have caused the failure in Fig. 16.

FIG. 17. A mill defect, an extremely bad inside seam running the full tube length, caused this failure. Note the numerous transverse cracks.

ft ±) than the length of the defective pipe (5800 ft), the string was completed at the top with other drill pipe. The experimental pipe was run on the bottom, where the service is most severe. As stated before, however, adequate drill collar weight was maintained and the drill pipe was intended to be in tension at all times.

During the drilling of the seven wells there were 17 failures, but 3 were tool joint breaks. Of the 14 pipe failures there were 3, properly recorded as to tube numbers, which were mislaid before being sent back to the mill for study.

Of the 14 there were nine Grade D failures and 4 Grade E and one unknown (lost). As there were originally 64 Grade D tubes and 136 Grade E, it would seem that Grade E is better suited for this type of drilling. The writer is not at all convinced, however, that this is proved as other factors, such as the treatments of the inside surface, exert much more influence than grade of steel.

Probably of much greater significance is the fact that there were no failures in plastic coated tubes. Of the 14 pipe failures there were 6 in untreated (scaled)

The defect was another of the "horrible" inside seams, heretofore described, running the whole length of the tube. Again it is evident that the curled-up outer edge of the seam (overlap) had corroded to paper thinness and then developed numerous transverse cracks. Two of these, one near the top and one near the bottom of the photograph, finally penetrated entirely through the wall, both at about the same time. Under "Type of Failure" a Stanolind field engineer had very briefly written, "Fatigue, 2 places."

Incidentally, this was one of the final three failures, in the last well, all of which showed "Fatigue, 2 places," and which led to retiring the string. The other two pipe failures, which were double fractures, were entirely unassociated with mill defects. Both were definitely the result of corrosion fatigue. Both happened to be Grade E, one being shot blasted and shot peened and the other untreated (with original mill scale on the inside).

Summary

Combining the data of both the Thompson-Carr and the Stanolind strings, we have:

Type of Defect	Number of Lengths
Inside seams	216
Outside seams	37
Inside pits	2
Outside pits	28
No defect (added to complete string)	1
	284

During the life of the two strings the following pipe failures developed:

Pure fatigue (no notches or corrosion discernible)	4
Notch fatigue (in slip marks)	4
Notch fatigue (origin of scars unknown)	3
Corrosion fatigue	3
Failures not picked up for study	9
Failures directly associated with mill defects	4
Failures seemingly associated with mill defects	1
	28

Assuming, then, that the last five failures listed above definitely were caused by mill defects, the percentage is about 1.8 per cent of the total under test. This is surprisingly small in view of the fact that all but one of the 284 tubes involved had been rejected by the mill inspectors and were destined for the scrap shears.

Several of the discussers of the original Thompson-Texter paper felt that corrosion fatigue failures occurred so rapidly as to mask rather than accentuate the influence of mill defects. In the second and third strings, however, steps were taken to delay corrosion fatigue and were so effective that out of a total of 28 failures there were only three definite cases of corrosion fatigue. In the first string there were 21 out of 21 that were true cases.

Therefore, it can now be said more positively than ever before that the ordinary types of mill defects—seams, pits, scores, etc., (inside or outside) well beyond the API allowable—are negligible factors in causing drill pipe failures. The four cases cited, in which the defects definitely resulted in failures, were quite extra-ordinary. They were all inside seams, very bad ones, and the tubes needed only very casual observation to discover them.

It is worthwhile to note, and may be of some slight comfort to drill pipe users, that not one of the fatal defects resulted in a fishing job. All showed up as washed out cracks, but, of course, eventually would have resulted in complete breaks.

So far, then, as a result of three field tests on rejected drill pipe, we have found the limit as to what depth or shape of inside seams can be tolerated, but we still have not reached the limit on outside seams nor of either outside or inside pits. It would seem that further field trials are needed to establish limits on these latter types of defects.

Acknowledgment

Aside from the invaluable services of Thompson-Carr, Inc., and the Stanolind Oil and Gas Company, in carrying on the rather hazardous field work, considerable credit is also due to William F. Schmeling for collecting the voluminous field data and to D. C. Neely for sorting out and properly tabulating it. These men are Spang-Chalfant field engineers.

Reference

A. W. Thompson and H. G. Texter, "Field Test on Rejected Drill Pipe." Drilling and Production Practice, 87 (1948).

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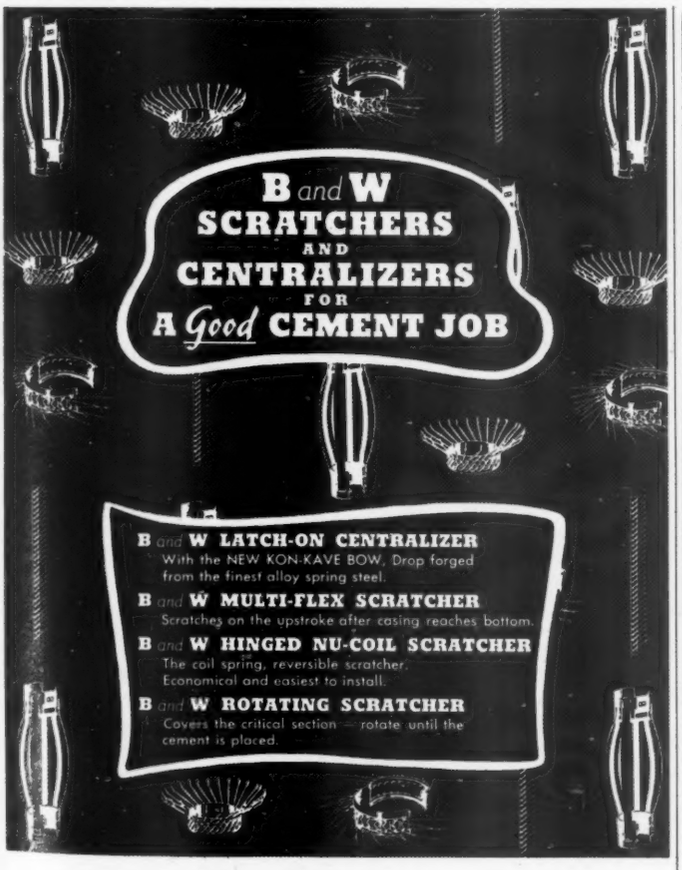
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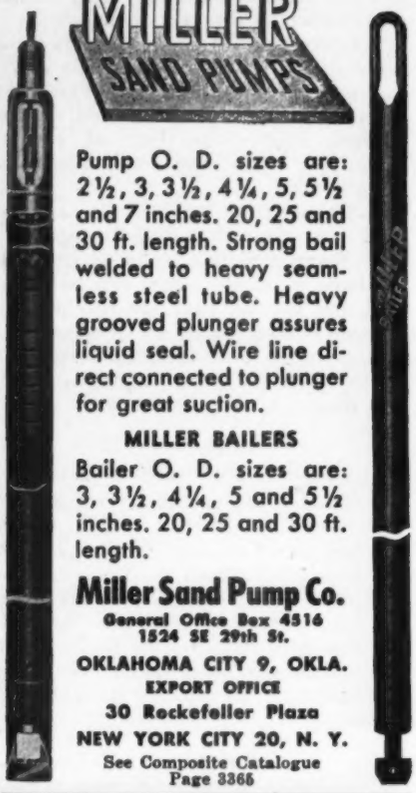

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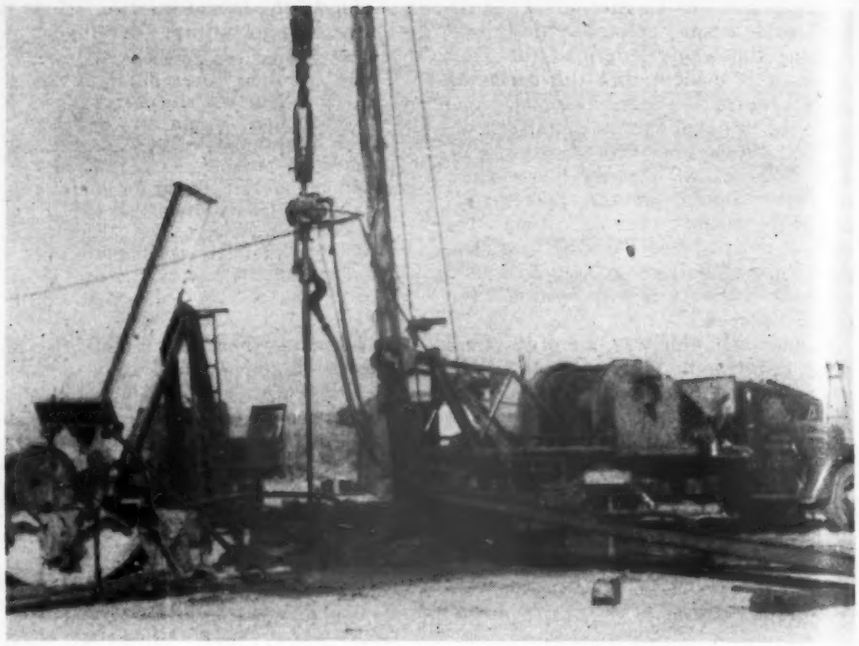


Power swivel being used for drilling.

Economical Work-Over Jobs

W. J. ALBRIGHT

THE scope of oil well servicing is commonly thought to include that of pulling rods and tubing, to make necessary corrections and get the producing well back on production as soon as possible. Through the swabbing of wells the oil well service companies have long been a necessary aid in the completing and testing of new wells and also in "kicking off" old wells, which have loaded up and failed to flow.

Recently a new service has been introduced, which has proved economical to oil companies. In many cases it speeds up a job that would take more time if a work-over rig were moved in.

In this new phase of well servicing the work is in conjunction with a rental tool company, which has the necessary equipment to make a rotary work-over rig out of a well servicing unit. Equipment needed is a power swivel or a Guiberson rotating head, a kelly, a swivel, and a small pump, which can be rented as a unit on a daily basis.

One recent work-over job was to set a bridge plug in the casing to dump cement on top to perforate the casing, to acidize through perforations, and to swab the well after the acidization. When the well was tested and ready to put on production the bridge plug was drilled out with tubing. The entire job was perforated without a work-over rig. It is readily apparent that the cost would have been considerably more had a work-over rig been used. Of course, the most practical use of a well servicing unit for a job of this nature is when there is not a great deal of drilling to do, as the cost to drill almost equals the cost of having a work-over rig. Twenty feet of new hole, however, were drilled by the above mentioned procedure.

In conclusion this is an economical way of doing a work-over job when there is little drilling to be done. * * *

The Author

W. J. Albright is head of his own company, Albright Well Servicing Company, which he organized in 1948. A former student of Oklahoma A and M College, Albright was a roustabout and roughneck, working for Halliburton Oil Well Cementing Company one and one-half years. He was in the armed service for three and one-half years, and upon returning was station manager for Dowell Chemical Company for two years.

New Unit Agreement Set Up In Kettleman Hills Field

Plans for a unit operating agreement for the Kettleman Hills North Dome field, California, were announced by Standard Oil Company of California. Under terms of the agreement, all pools within the field are to be operated as a unit, by a single operator, for the participating companies. Parties to the agreement have chosen Standard to operate this unitized producing area.

In announcing these plans, it was stated that unitization will permit more efficient overall operation, yielding maximum ultimate recovery of oil, gas and associated hydrocarbons. Approval of the Secretary of Interior is necessary because most of the land operated by KNDA is owned by the United States.

Standard also has announced that in order to meet requirements of the new unit operations it intends to offer employment to "as many KNDA employees as it will need to add to its work force because of the unitization."

Production Said Dropping In Russian Baku Wells

According to American diplomatic reports the Russian Baku oil fields are drying up seriously. Output is reported to have fallen off so sharply that the Russians are resorting to desperate measure to tap underwater wells in the Caspian Sea. Though these wells lie some distance offshore and involve costly drilling, the Russians are reported pushing operations night and day.

Russian oil demands have been largely increased within the last two years as a result of large-scale mechanization program of the armed forces.

Saudi Arabian Output

Crude oil production in Saudi Arabia during October amounted to 23,713,838 bbl, or an average of 764,963 bbl per calendar day, it was announced by the Arabian American Oil Company. Crude oil production for the first 10 months of 1952 amounted to 256,220,459 bbl, an average of 840,067 bbl per calendar day.

Oil Recovery Project for Osage County Proposed

An estimated 8,000,000 bbl of oil may be recovered by flooding the underground sands of the Quapaw reservoir in Osage County, Oklahoma, with water and flushing the oil into producing wells, according to a petroleum-engineering report released by J. J. Forbes, director of the Bureau of Mines, Department of the Interior.

Presenting the results of a study made in co-operation with the state of Oklahoma, the report is published as a part of the Bureau's program to stimulate secondary oil-recovery practices throughout the United States. Bureau engineers feel that it should be especially useful because the Quapaw reservoir is representative of many small pools in the area. Completion of the discovery well in 1914 at a depth of 1762 ft, stimulated rapid development, according to the report. A proved area of 3095 acres was defined by completion of approximately 275 wells during the next five years.

Unrestricted production dissipated the reservoir energy quickly, and pumps were installed on all wells soon after they were completed. Primary production methods recovered approximately 6,500,000 barrels of oil, the report states, only 15 per cent of the original stock tank oil in place.

The total recovery to January 1, 1952, of 8,486,946 bbl of liquid hydrocarbons is equivalent to only 35 per cent of the original oil in place in the reservoir, according to the report.

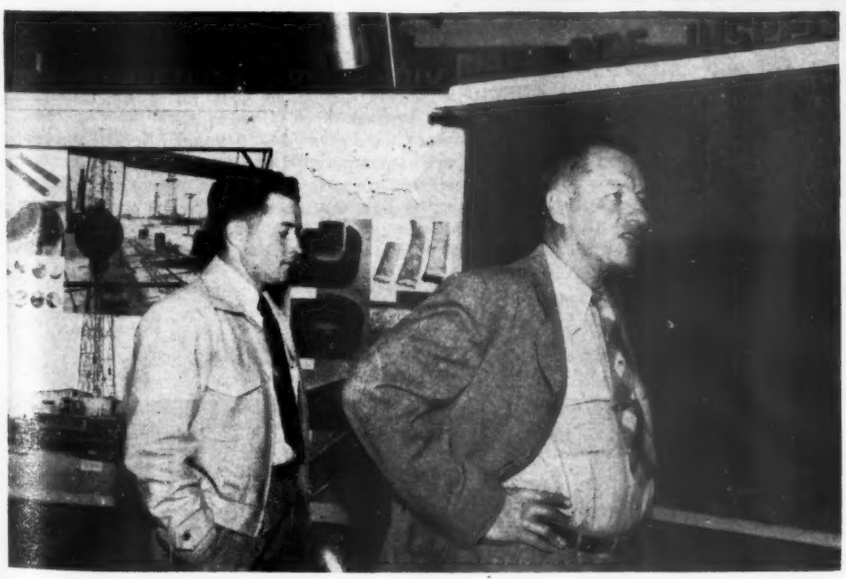
Written by James A. West, former Bureau petroleum engineer, the report describes the history and development of the Quapaw pool. A free copy of Report of Investigations 4913, "Petroleum-Engineering Study of the Quapaw Pool, Osage County, Oklahoma," with 74 pages and 26 illustrations, may be obtained from the Bureau of Mines Publications Section, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

Costs of Drilling Mounts IPAA Committee Shows

Cost of finding, developing, and producing a barrel of crude oil was more than 60 cents higher in the first six months of 1952 than in the three-year period 1947-49. This represents a cost increase of 38 per cent to domestic oil producers who have realized an average price increase of only 6.6 per cent in the same period, the Cost Study Committee of the Independent Petroleum Association of America reported in Oklahoma City recently.

James V. Brown, committee chairman, said a further increase in cost of 15 cents a barrel will be reflected in the last half of the year because of increased wages, construction costs, and steel prices paid by the industry.

He said recent costs increases, not reflected in the first six months of the year, include a 7.5 per cent hike in wages and salaries, a 6.5 per cent increase in steel prices, and a 5.24 per cent gain in construction costs.



Attending the Permian Basin oil show held in Odessa, Texas, recently, are: Harry Zane, sales manager; Alex Smith, vice president, and general manager, Dolton Moss, and E. W. Nolan, Jr., Guiberson Corporation. At left is Tom Kent, field engineer, and George L. Dehn, southwestern manager, Magnaflux Corp.

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API Production Men Make Up Committees

The Division of Production of the American Petroleum Institute, elected 45 members of the general committee of the production division for 1953, at its annual meeting recently. They include:

Jack H. Abernathy, Big Chief Drilling; C. W. Alcorn, Falcon-Seaboard; R. B. Anderson, Columbian Carbon; C. E. Beecher, Cities Service; A. H. Bell, Bell and Burden; Paul G. Benedum, Hiawatha; P. H. Bohart, Gulf; S. F. Bowlby, Shell; George E. Cannon, Humble; Jack Cashell, Preston Oil; A. E. Chester, Magnolia; D. L. Connelly, Warren; L. A. Cranson, Honolulu; Harold Decker, Houston Oil; W. B. Emery, Ohio Oil; E. R. Filley, Texaco; L. E. Fitzjarrald, Phillips; David Frame, Humble; R. H. Green, Signal; John Hancock, Hancock; H. H. Healy, Ohio Oil; John E. Howell, Lion; H. B. Hurley, Republic Natural Gas; J. C. Johnston, Continental Oil; J. W. Jordan, Sinclair; Basil P. Kantzer, Union; R. C. Kay, independent; R. B. Kelly, Pure Oil; J. R. McMillan, Fullerton Oil; H. E. Miller, Globe; C. L. Pickett, California Company; D. T. Ring, Waverly Oil; John A. Ritter, Sun; J. J. Schmidt, East Ohio Gas; A. L. Solliday, Stanolind; L. A. Sunkel, Atlantic; R. O. Swayze, General Petroleum; A. W. Thompson, Thompson-Carr; E. H. Tollefson, Hope Natural Gas; J. E. Toussaint, Standard; W. J. Travers, Richfield; A. K. Tyson, American Republics; E. W. Webb, Continental; F. H. Willibrand, Sohio; M. A. Wright, Carter.

Simultaneously Frank M. Porter, Institute president, announced the appointment of 5 members of the API board of directors to the production general committee, as follows:

John R. Suman, Standard Jersey; John M. Lovejov, Seaboard; Jake L. Hamon, Jake L. Hamon; A. K. Brinkerhoff, Jr., Brinkerhoff Drilling, and A. Jacobson, Amerada.

Recovery Group Meets

The Texas Petroleum Research Committee is holdings its fifth Oil Recovery Conference at Texas A & M College this month. Theme of the conference is "Use of General Purpose Punched Card Computing Systems in Solving Petroleum Engineering Problems." Papers being presented describe methods of problem solution that will save the engineer hours of tedious calculations.

Century Geophysical Holds Annual Field Meeting

The second annual meeting of field personnel was held recently by Century Geophysical Corporation, in Tulsa, Oklahoma. Representatives of Century's seven domestic crews and one Canadian crew were present. Hosts for this meeting were Opie Dimmick, Century president, and Ben F. Rummerfield, vice president.

The two-day session was taken up with discussions of operational problems, study of new equipment, company policies and tour of manufacturing facilities. A similar meeting was held recently for Canadian personnel at Calgary.

Attending were: Front row, L. W. Hoar, M. I. Williams, Charles L. Mackey, W. J. Masterson, Mrs. Jerry Cox, Mrs. Mary E. Horn, Opie Dimmick, A. V. Simonson, Mrs. Effie Power, G. D. Jett, P. I. Bediz, Neal Clayton, David Weichert, and Gordon Smith. Back row: J. B. Bender, Tom Mount, Teddy Greer, Charles E. Singleton, Walter T. Primm, Harold Read, Ben F. Rummerfield, George Tibbs, T. J. Ray, Jr., W. E. Olsen, J. H. Werlin, and G. W. Rentschler.

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Sunray Combines California Mid-Continent Divisions

A re-alignment of executive personnel in order to combine the operations of its Mid-Continent and California division properties was announced by C. H. Wright, chairman, and W. C. Whaley, president of Sunray Oil Corporation.

At a special meeting, the board of directors confirmed the appointment of Paul E. Taliaferro to a new position as executive vice president of Sunray. Taliaferro is a director of Sunray and has been a vice president and assistant to the president.

H. O. Harder, who since 1949 has been vice president and manager of Sunray's Mid-Continent production division, has been named vice president and manager of Sunray's exploration department, including geological and land divisions, operating in all areas of both the Mid-Continent and California divisions.

R. E. Foss, who since 1951, has been a vice president for Sunray's California division with headquarters in Los Angeles, will move to Tulsa to become vice president and manager of the company's exploitation department, including drilling and producing activities throughout the Mid-Continent states and California.

H. W. Manley, who has been a vice president since 1951, and since 1952, vice president and manager of the company's manufacturing, sales, and pipe line division, will also assume responsibilities for the management of the company's manufacturing, sales, and pipe line activities in California.

In announcing the executive changes incident to a re-alignment of operating responsibility among the officers concerned and which are effective immediately, Chairman Wright and President Whaley said that the new line-up will consolidate executive management of the operating divisions of Sunray Oil Corporation in Tulsa where the company's general offices are established.

IOCC Reports Available

The Interstate Oil Compact Commission has announced the publication of three reports dealing with secondary recovery operations in Arkansas, Indiana, and New Mexico in 1951.

Report on Arkansas was made by Walter L. Dodie, chairman of Arkansas Oil and Gas Commission, in cooperation with the Secondary Recovery Division of the Commission. This report gives data on nine active projects in Arkansas together with four projects that have been abandoned.

New Mexico report, prepared by Glenn Staley, chairman, and R. R. Spurrier, vice chairman, has descriptions of 4 projects operating in that state. It also contains 3 maps and 18 charts. A map of southeastern New Mexico oil fields is included with this report.

Homer R. Brown, chairman of the Secondary Recovery Committee for Indiana in cooperation with the Secondary Recovery Division, Interstate Oil Compact Commission, has prepared the report on Indiana. It contains descriptions of three pools that have been waterflooded, and numerous illustrations.

All reports may be received from the Headquarters Office, Interstate Oil Compact Commission, Box 3127, Oklahoma City.

Maps Show Portion of Williston Basin Area

O. F. Warren of Great Northern Map Company, 619 South Detroit, Tulsa, Oklahoma, has announced completion of current abstract and township maps covering Williams and McKensie counties' portions of the Williston Basin. These maps, drawn on scale 3 in. to 1 mile, are well prepared from a study of records by legally trained personnel.

Phillips Organizes New Exploration Division

Phillips Petroleum Company has announced the organization of a new exploration division in Denver, Colorado. Joint land and geological exploration offices in Salt Lake City will be consolidated with the Denver office, on January 1, officials reported. Dr. Orlo E. Childs will be in charge of the division.

Exploration offices will be maintained in Salt Lake City, Grand Junction, Colorado, Centralia, Washington, and Thermopolis, Wyoming, but land geological department representatives will operate out of Denver.

Carter Sets Up Two New Field Offices

Carter Oil Company has established two field offices to expedite its operation. One is to be situated at Liberal, Kansas, with C. Don Geiger, area geologist, in charge. Assisting him will be James B. Nance, John R. Lathrop, and Clayton L. Roloson, production geologists; Herbert W. Collier, land man; Robert H. Harman, scout, and Roy Kelly, production foreman.

The second office will be situated in Elk City, Oklahoma. W. W. Solter, area geologist, will be in charge of the office and assisting him will be James B. Coffman, production geologist; Don D. Hendrie, and Thomas E. Witty, geologists; Thomas K. Levy, geophysical interpreter, and William L. Moore, land man.

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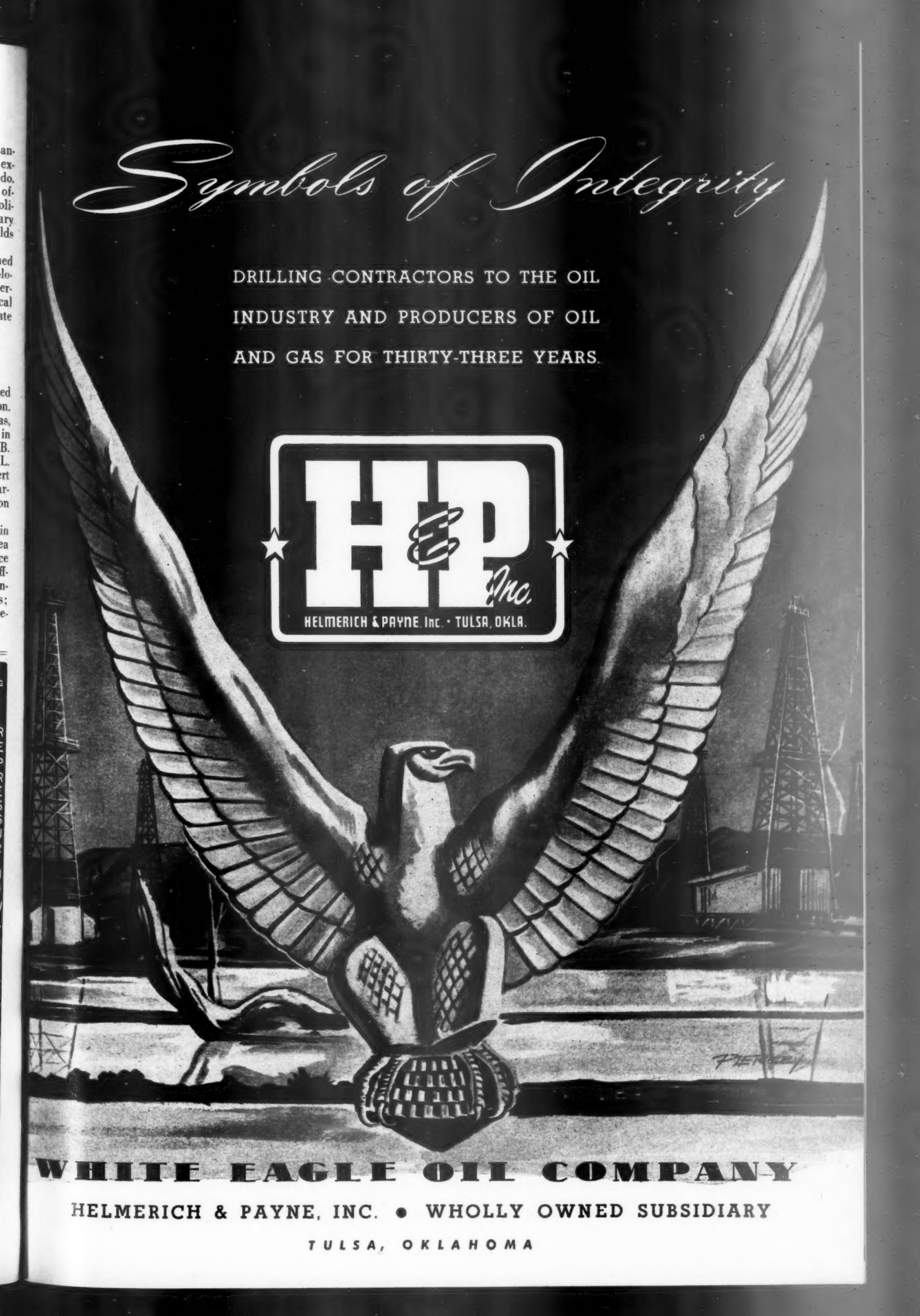
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What's Doing in Drilling

Carter Completes Well In Anadarko Basin

Carter Oil Company has completed its No. 3 Sid Sharp in Beaver County, Oklahoma, for 110 bbl of 39.7 gravity oil in 24 hr. The well was drilled to a total depth of 5840 ft for 110 bbl of 39.7 gravity oil in 24 hr by swabbing. With the oil, it made seven barrels of brackish water. Production came after treatment with 100 gal of acid. With the oil was 100,000 cu ft of gas for a gas-oil ratio of 900 to 1. Production was from perforations in the lower Oswego lime between 5798-5830 ft.

Tide Water Brings in Two California Wells

Tide Water Associated Oil Company, Western Division, has announced the successful completion of its Lloyd No. 170 well, Ventura Avenue field, California, flowing at the rate of 580 bbl per day from a total depth of 11,141 ft.

Another well has been successfully completed by Tide Water in the Ventura Avenue field. It is the Hartman No. 44 well, flowing at the rate of 538 bbl per day, gravity of 33.6, from a total depth of 11,420 ft.

Field Well Flows at Rate Of 11,000,000 Cu Ft Gas

J. R. Butler et al have reported open flow potential at their No. 1 Mayfair Park, Inc., 3300-ft east extension of North Blue Ridge Vicksburg pool, Harris County, Texas. Open flow potential shows the well to be good for 11,000,000 cu ft of gas per day with production of 62.1 gravity distillate under gas-liquid ratio of 23,000 to 1. Tubing pressure was 2719 psi.

Union Hits New Zone In Louisiana Field

Union Producing Company has indications of a new producing zone in the Bourg field, Terrebonne Parish, at its No. 2 Barrow. Flowing through perforations 11,408-422, the well flowed 227 bbl of 50.7 gravity distillate plus 9,319,000 cu ft of gas daily on 5/16-in. choke under 4168 psi, tubing pressure. Gas-oil ratio measured 41,502-1.

Third Well Successful In Kansas Oil Field

The third big producer for the Northwest Oscar pool of Stafford County, Kansas, was completed recently by Cities Service Oil Company for an initial potential of 1214 bbl of oil daily. This is the company's second producer in the newly-discovered field. Latest Cities Service completion is Smith N-1, which is producing from perforations in the Lansing-Kansas City limestone from 3585 to 3600 ft. Lansing-Kansas City was topped at 3467 ft.

Rotary Rigs Operating in Oil Fields of United States and Canada*

Weeks	Total	Gulf Coast	Pacific Oil	Illinois Oklahoma Kansas	Rocky Mountain Canada	West Texas New Mexico	Arkansas Louisiana Texas	North Texas
(October)								
Third	2764	593	167	626	447	481	154	296
Fourth	2753	568	170	634	444	486	153	298
(November)								
First	2768	590	170	635	426	496	153	298
Second	2806	598	169	640	415	514	143	327

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

Oceanic Drills New Well In Kern County, California

Oceanic Oil Company has reported a new well, its General American No. 1, in Kern County, California. The well has been completed, pumping at the rate of 192 bbl of 22 gravity crude oil with 17 per cent emulsion and water.

Producing from Miocene oil sands below the shallow oil horizons of the old producing area in the Midway-Sunset district, the well is gun perforated between 4312 and 4330 ft.

Alabama Well Completed

Stanolind Oil and Gas Company has a successful completion in the Pollard field of Escambia County, Alabama. It is the No. A-2 St. Regis Paper Company, most westerly producer in the field. Flowing at the rate of 338 bbl of oil per day through 10/64-in. choke, the well was completed from Pilot Sand perforations 5870-74 ft. Tubing pressure was 200 lb and gravity of oil 29 deg.

Oklahoma Pool Gets Third Producing Zone

Mid-Continent Petroleum Company has a third productive well in the North Tipton field of Jackson County, Oklahoma. The well, a north offset to the pool discovery, hit the top of the canyon lime at 1907 and the Strawn zone at 2112 ft. A 1-hr test at 2177-85 ft showed gas in 21 min and recovered 420 ft of 39.9 gravity oil and 720 ft of salt water. On a second test at 2207-21 ft, the 1-hr opening showed gas in 7 min and recovered 1268 ft of oil.

Mississippi Well Confirms New Commencement Field

Barnett Serio and Norman Germany have completed their No. 1 George W. Armstrong in Adams County, Mississippi, as a confirmation well to the Commencement field. On potential test the well flowed at the rate of 142 bbl of oil per day plus 0.8 per cent paraffin through 10/62-in. choke. Tubing pressure was 490 lb gravity of oil 39.8 deg and gas-oil ratio 200 to 1. Production is from casing perforations 6540-44 ft opposite the Walker sand zone. Hole was drilled to 6722 ft and cased with 5½ in. pipe to 6605 ft for the completion.

Humble Completes Two Alabama Field Wells

Humble Oil and Refining Company has completed its No. 4 L. G. Crosby in the west section of the Pollard field of Escambia County, Alabama. Completed at the rate of 81 bbl of oil per day through ⅛-in. choke, the well was drilled to 5860 ft and cased with 5½-in. pipe to total depth for completion. Tubing pressure was 100 lb and oil gravity 27.6 deg. Production is casing perforations 5852-56 ft opposite the Pilot Sand of Lower Tuscaloosa.

The company's A. W. Moye No. 4 was completed for a daily flowing rate of 42 bbl of 26.1 gravity oil, through a ¼-in. choke and from casing perforations at 6090 to 6095 ft.

Bufkin May Have New Zone In Grogan Field, Louisiana

A new zone discovery is apparent for the Grogan field of DeSoto Paris, Louisiana, at R. P. Bufkins's No. 1 Mary Yancy. Approximately 42 ft of saturated sand in the Nacatoch has been indicated by electrical log at 1203-45 ft. String of 5½-in. casing was cemented at 1200 ft, plug drilled, and tubing run. At latest report, the well was clearing through ⅛-in. choke flowing at the rate of 130 bbl of oil per day. No formation water was reported and gravity of oil is about 38 deg. Nearest Nacatoch production lies about 8 miles to the southwest.

Montana Gas Field Gets Oil

The Texas Company has found oil in the Bowes gas field in Blaine County, Montana, underlying the shallow gas sands. The new producer is the State "C" No. 6 well, with an initial of 150 bbl from the Sawtooth sand, following acidization with 4000 gal. It is a south offset to Northern Ordnance-No. 12 Guertzgen, also a good well.

Shell Producer Completed

Shell Oil Company has completed a good oil and gas producer in Beckham County sector of the Elk City field. It is the company's No. 3 Kelly "D" plugged back to 10,454 ft. The well flowed 979 bbl of 50.5 gravity oil in 24 hr through a 22/64-in. choke from perforations between 9938-10,026 ft. Gas-oil ratio was 1532 to 1.

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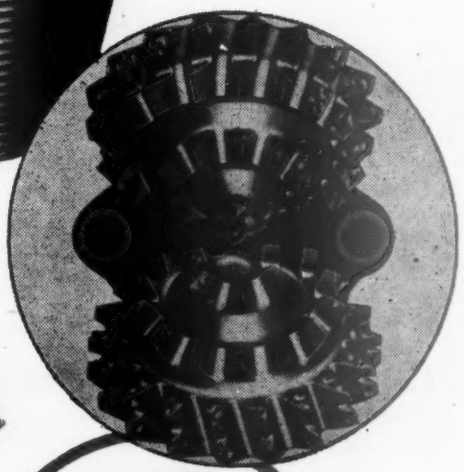

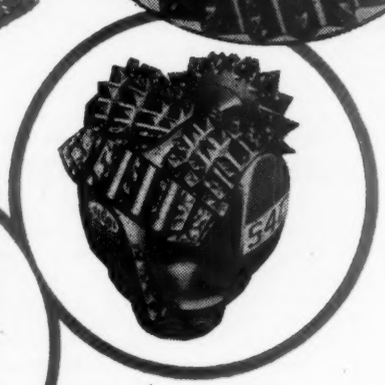

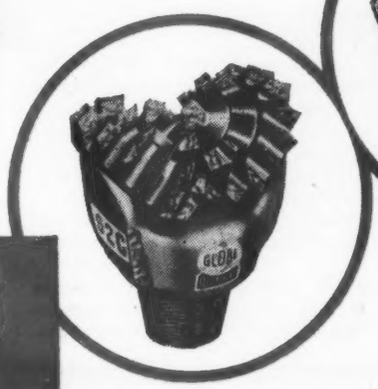

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West Texas Test Deepened

Anderson-Prichard Oil Corporation and J. C. Barnes have announced plans to re-enter the No. 1 University "E" well, a San Andres dry hole in Northeast Andrews County, Texas, test. It will be deepened and tested to the Ellenburger. The 5886-ft dry hole will be deepened to about 13,500 ft. Nearest Ellenburger production is in the Magutex field five and half miles southwest.

Conoco Hits Third Oil Zone

Continental Oil Company has made perforations for a third producing oil zone in the Camp Pool, Carter County, Oklahoma. The Humphrey sand is being tested in Conoco's No. 1 Martin-D. Some showing was made in the Goodwin at 6202-50 and the Sims at 6138-88 ft, and plug was set at 5870 ft and series of holes made from 5725 to 5850 ft. Approximately 1300 ft of oil was found in the hole in 9 hr.

Humble Completes Gas Well

Humble Oil and Refining Company has completed a new well in Terrebonne Parish, Louisiana, flowing at the rate of 3,707,000 cu ft of gas and 9.3 bbl of 50.6 gravity condensate per day. It is the company's No. E-4 Louisiana Land and Exploration Company, which was given a gas-condensate ratio of 399,000 to 1. Flowing tubing pressure was 2400 lb. Casing perforations were at 7140-43 ft.

Stanolind Completes New Dual-Producer Well

Stanolind Oil and Gas Company has completed a dual producer in the Fox-Graham field of Garvin County, Oklahoma. It is the company's No. 2 Noah, which perforated the Deese topped at 3480 ft in a series between 3484-4055 ft. The well flowed 30 bbl of 31.5 gravity oil per hour. The Sycamore was topped at 4808 and perforated between 4928 and 5035 ft and showed 47 bbl of 36 gravity oil with 4 bbl of water in 8 hr.

Canadian Pool Extended

Socony-Vacuum Exploration Company has extended the Centaur oil pool in Saskatchewan with completion of its No. 30-8B Socony-Western Prairie Beverley No. 30-8B. Completed at 3255 ft, the well and other similar Socony wells in the general area about Fosterton in Saskatchewan have resulted in that province's best hope to date for substantial medium gravity oil production. Previous output had been all heavy crude—up to about 16 deg gravity.

New Sand Added to Pool

A new Red Fork sand producer has been added to the Northeast Mammoth pool in Lincoln County, Oklahoma. The Texas Company's No. 1 Mathews was bottomed at 4646 ft with casing set at 4627 ft. The well flowed 37 bbl of oil in 10 hr through a ¼-in. choke.

Kentucky Test Deepened

Skiles Oil Corporation has completed its No. 1 G. E. Parker in Hopkins County, Kentucky, for 96 bbl of oil a day on the pump. The new well is a reworked abandoned test well, originally abandoned as a "dry hole" in May at a total depth of 3041 ft. The well is producing from the Cypress sand at 2590 ft to 2604 ft. The new well is more than 2 miles from present production.

Bishop Completes Two Wells In Kern County, California

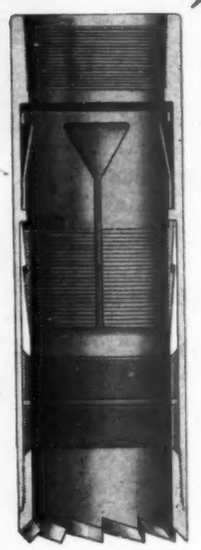
Bishop Oil Company has announced completion of two new wells to production in Kern County, California. The wells, Nos. 25 and 26 on the company's Barnsdall-Signal lease, gave initial combined production of 54 bbl of 21 deg gravity oil per day. They were drilled to depths of 1430 and 1420 ft respectively. Well No. 27 on the same lease was abandoned as unproductive at 1660 ft.

Reef Production Seen In Louisiana Field

Possible reef production is seen in the new Summerfield field in Claiborne Parish, Louisiana. Two confirmation tests are being made to test the Smackover by Magnolia Petroleum Company, which is coring below 11,284 ft at the No. 1 Drew F. Hightower, southeast of the discovery well in the field. Casing will be run to test possible Smackover production, which was logged approximately 700 ft below the interval in which pay was found in the discovery well to indicate a sharp buildup of reef.

THE PACKER TYPE
BOWEN RELEASING CASING BOWL
provides the economical, fast, safe way to repair defective casing

Packer Type Bowen Releasing Casing Bowls are used with great effectiveness in wells with casing difficulties. The standard procedure is to make a cut with an Internal Cutter in the casing immediately below the damaged area and to pull the casing from the hole. The damaged portion of the casing string is then replaced with good casing. A Packer Type Bowen Releasing Casing Bowl is then installed on the bottom end and lowered over the casing in the hole. When upward pull is exerted, the tapers on the Cone contracts the Slips into secure engagements with the casing and the Cone bears against and compresses the lead Packing into a leakproof seal around the casing.



DOES NOT REDUCE HOLE DIAMETER

The bore of this tool is always either the same or larger than the inside diameter of the casing on which it is to run, so that there is no impairment of any inside-the-casing operations.

OUTSTANDING RELEASE FEATURE

The releasing feature which is outstanding in the Packer Type Bowen Releasing Casing Bowl is very valuable. Should hole conditions prevent a perfect pack-off, the tool can be released and the casing again withdrawn without the expense of making an additional cut with an Internal Cutter. After the necessary corrections have been made, the tool can again be run in the hole and engaged with the casing. The releasing feature has been found to be advantageous in other instances where the operator has decided to abandon the well shortly after the tool was set because at practically no expense he can salvage the casing above the Packer Type Bowen Releasing Casing Bowl.

Release is effected by bumping down and rotating to the right. This hangs the Slip in its uppermost position. When in this position, the Slip cannot be contracted against the casing by the tapers on the Cone and the tool easily can be withdrawn.

Mill Type Guides and Oversize Guides are available for all Packer Type Bowen Releasing Casing Bowls. Mill Type Guides prove very advantageous in those instances where sand conditions necessitate washing-over operations. Oversize Guides insure alignment with the casing in large holes.

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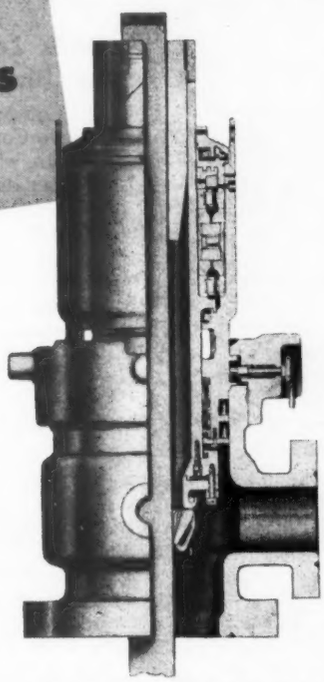
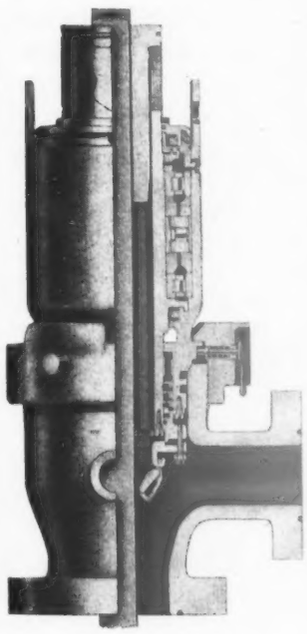




Both Feature the Same Field-Proven Safety and Operating Advantages!

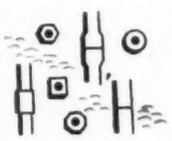
For years, the Shaffer Type 50 Combination Rotating Blowout Preventer and Stripper has been depended upon by leading operators to provide *automatic* protection against pressure emergencies while drilling. Now, to meet the wide-spread demand for a smaller unit to provide the same dependable protection, Shaffer brings you the *new* Type 51 Combination Rotating Blowout Preventer and Stripper.

The new Type 51 incorporates the same foolproof sealing principle, the same wide-range versatility and safety—except that it is of smaller size to make it more readily adaptable to various classes of work.

USE THE TYPE 50
for all kinds of drilling operations . . . and it is especially recommended for use in drilling through 10¾" casing and larger.

USE THE TYPE 51
for protecting against blowouts in slim hole drilling, drilling-in, production jobs, reworking of wells and remedial work.

Both Type 50 and Type 51 incorporate these unique advantages . . .



Seals Varying Diameters and Shapes
In both units, the Stripper Rubber expands and contracts **automatically** to fit the varying diameters and shapes of the drill string (excepting such abnormally large diameters as bits and reamers). It seals around any shape—round, square, hexagonal or octagonal—and varying diameters of pipe, couplings, drill collars, subs, etc. **No manual adjustment is necessary!**

Unusually Compact
Both units are amazingly compact and can be installed under even the most difficult space limitations. Not only are vertical and horizontal dimensions kept to the minimum, but even the flow connections are built directly into the body, simplifying hook-ups and eliminating need for spools or similar equipment.

Continuous Seal
A pressure-tight seal is maintained without need for applying mechanical or hydraulic pressure of any kind from the outside . . . and the seal **automatically** adjusts itself to the varying shapes and sizes in the drill string. The operator can **drill** under pressure, and can also **strip** pipe in and out of the well under pressure—**all without adjustments or changes in the unit!**

Steel Protected Stripper Rubber
A patented expandable barrier of hinged steel latches prevents the Stripper Rubber from extruding—either by high pressure or by pulling large diameters through it. Yet full flexibility of the rubber is assured.

Unusually Long Life
The Stripper Assembly rotates freely with the kelly—not one inside the other. Thus, there is virtually no wear on the rubber, assuring negligible maintenance and maximum safety. The bearing assembly upon which the unit rotates has separate thrust and radial bearings to withstand any combination of loads due to high pressure and high speed drilling—and bearings are prepacked with a high temperature and high speed stabilized grease.

Passes Large Diameters
Unusually large-diameter tools such as bits and reamers can be passed through the unit with maximum ease, safety and simplicity by merely pulling a spring latch, rotating the bonnet 1/6th turn, whereupon the entire internal mechanism can be withdrawn as a unit to permit passing the bit or reamer.

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Exploration Activities

Colorado Gets Largest Oil Flow To Date

Hiawatha Oil and Gas Company has brought in one of the largest oil flows in Colorado to date. The wildcat is situated in Jackson County, and flowed at the rate of 65 bbl an hour through ½-in. choke. Production zone is the first Frontier. Total depth is 6920 ft.

R. M. Thompson, regional exploration manager of Hiawatha, said the well has the highest flowing potential of any oil well in Colorado. Gravity of oil is 40.3, and contains no wax or paraffin. Also present is a large volume of gas that analyzes more than 87 per cent combustible, most of which is ethane and higher fractures. The well is being drilled by Hiawatha for Benedum Trees Oil and M. D. Davis, a Benedum Trees official.

Indiana Well Testing

The Morris Drilling Company has a new test well in Gibson County, Indiana, its No. 1 Frank McRoberts. The well is testing the Benoist sand from 1645 to 1649 ft, where the well is stopped in saturated sand. It swabbed at the rate of 120 bbl of oil a day, naturally, and is more than 1 mile from other production.

Louisiana Field Open

A new field, the Montz field, has been opened in St. Charles Parish, Louisiana, by the California Company's No. 1 R. L. Smart. Drilled to 11,504 ft, perforations were placed opposite gas sand 10,092-110 ft. On potential test the well was credited with flow at rate of 2,200,000 cu ft of dry gas per day through 10/64-in. choke.

Union Sulphur Drills Gas-Condensate Well

A new gas-condensate discovery has been made by Union Sulphur at its No. 1 Dewey Harmon, Acadia Parish, Louisiana. On drillstem test, the well indicated flow at the rate of 2,500,000 cu ft of gas plus 30 bbl of condensate per day through ⅛-in. choke.

Humble Drills Pool Opener

Humble Oil and Refining Company has completed its No. C-1, N. H. Breaux in Adams County, Mississippi, to open the new Lake Lucille field. Gravity of the oil is 46 deg, and tubing pressure ranged from 0 to 100 lb. The well was completed from perforations 6844-48 ft opposite Wilcox oil sand, and drilled to 7300 ft and cased to 6901 ft for completion.

Nebraska Discovery Made

Stanolind Oil and Gas Company has made a new oil discovery in Kimball County, Nebraska, at its No. 1 State. The well recovered 200 ft of oil at 6106-33 ft and 3032 ft of oil at 6107-33 ft.

Shell Drills Large Williston Basin Well

Shell Oil Company has a new discovery in McCone County, Montana, in the Williston Basin, which flowed at the rate of 1675 bbl per day. Oil was said to be 4914 gravity, highest yet reported in the Montana portion of the Williston Basin. It is the company's No. 21-33-B Northern Pacific. Initial flowing pressure was 600 lb and final pressure was 1375 lb with shut in pressure at 4560 lb. It is producing from the Silurian Ordovician formation.

New Kansas Field

The White Eagle No. 1 Koelsche wildcat in Stafford County, Kansas, has opened the new Koelsche field. The well was given a daily potential of 2583 bbl from 3750 to 3757 ft, and is producing from the Lansing Kansas City. It is a mile southeast of the Rattlesnake field.

Canada Has Open Flow Rate of 20,000,000 Cu Ft Per Day

The Pacific Petroleums — gas exploration team has announced that its Rycroft No. 2 gas well, in the Peace River area of Alberta, has been completed with an open flow potential of 20,000,000 cu ft per day of gas, with appreciable naphtha content.

This second well adds a very substantial gas reserve to that calculated in the Hume report when only one well had been drilled. Well was completed after perforating and swabbing the interval 3735-3760 ft.

Ohio Oil Has Big Gas Flow

Ohio Oil Company's No. 1 Spicknal in Cheyenne County, Nebraska, showed a gas flow of 3,430,000 cu ft daily in a test at 4613-23 ft. In another test at 4623-42 ft it flowed 3,022,000 cu ft and 2,100,000 cu ft at 4758-66 ft. Operator is coring below 4674 ft.

Texaco Well Completed

The Texas Company has completed its No. 1 Morehead in McClain County, Oklahoma, for a flow of 154 bbl of oil, without water, in 24 hr through a ¼-in. choke. Flow is from perforations between 8850-60 ft, plugged back to 8865 ft. Gas oil ratio was 823 to 1.

New Argentina Well Flows More Than 2000 Bbl a Day

A rich new oil pool has been reported in Campo Duran, in the province of Salta, Argentina, in the foothills of the Andes. Wildcatters, in a dispatch from Buenos Aires-Informaciones of Madrid reports that the discovery well hit the pay zone at 11,000 ft and showed a production capacity of more than 2000 bbl of oil daily, plus more than 20,000,000 cu ft of natural gas.

Wyoming Well Opens Mesaverde Production

Mesaverde production has been opened in Sweetwater County, Wyoming, in the Middle Mountain area. Pool opener is Stanolind Oil and Gas Company's No. 1 Unit, which after initial test, was shut in for market outlets. Casing was perforated at 6534-44 ft, and on a 12-hr test the well did 77 bbl of clean oil through a ¾-in. choke. Gas gaged 2,090,000 cu ft a day.

Amerada Brings in New North Dakota Well

Amerada Petroleum Corporation has opened its fifth pool in North Dakota at its No. 1 North Dakota, in McKenzie County. On completion test in the Madison, the well flowed 124 bbl of oil and 71 bbl of water together with 162,000 ft of gas on an 18-hr period. Tests were made at 8674-9720 ft.

New Mexico Pool Open

Sun Oil Company has opened the Bone Springs pool in Lea County, New Mexico, at its No. 1 Harper-Federal. The new well made 84 bbl of oil through various sized chokes from perforations at 11,662 to 11,669 ft. Crew washed the hole and swabbed 56 bbl and is still testing.

Tri-State Basin Well Brought in by Obering Oil

E. A. Obering Oil Company has completed a new well in the Tri-State Basin, in Washington County, Illinois. It is the company's No. 1 Kitowski, which was completed from the Trenton limestone at 3904 to 3934 ft with initial production gage of 182 bbl of oil a day on the pump. The well, which is four miles from present production from the Cypress sand — a shallow sand — was acidized with 2500 gal. It is more than 11 miles from the nearest Trenton sand.

Texas Oil Discovery Seen

A new oil discovery for Callahan County, Texas, is assured at Cities Service Oil Company's Johnson L No. 1 wildcat, where the company is testing the Gray sandstones.

This sandstone was perforated from 3663 to 3674 ft and, after sand-fracing, the well flowed 72 bbl of new oil in 11-hr after recovery of the load oil. The 72-bbl test was through a ¼-in. choke and flowing tubing pressure was 850 lb. The gas oil ratio is 1000 to 1.

Kansas Pool Opener Seen

B. & R. Drilling Company has a large wildcat in Rooks County, Kansas, the No. 1 Schneider "B." Flowing from the Arbuckle formation, the new well was given a potential of 178 bbl daily. Flow is from 3667 to 3825 ft. The new well opens the Laura South pool.

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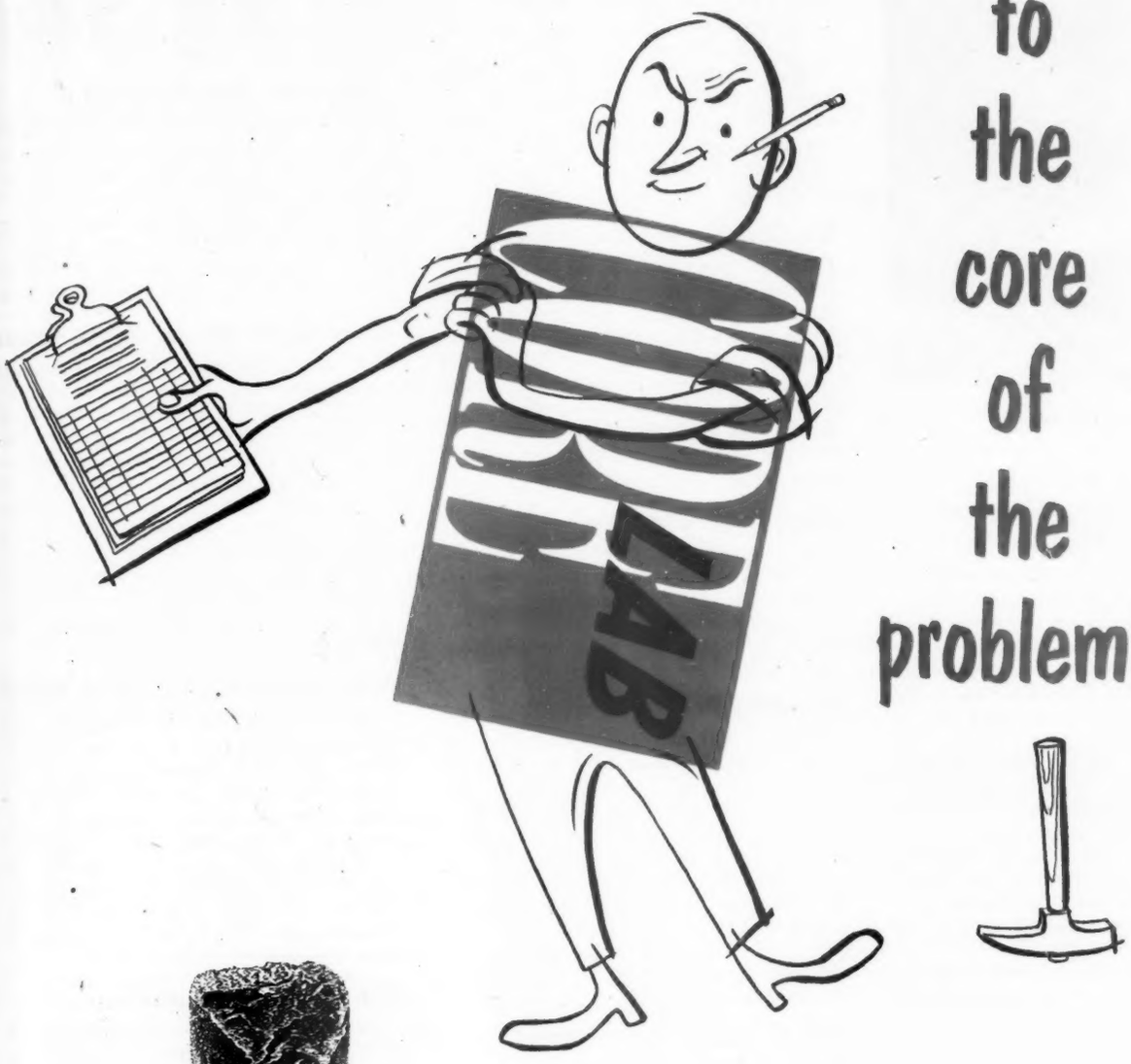

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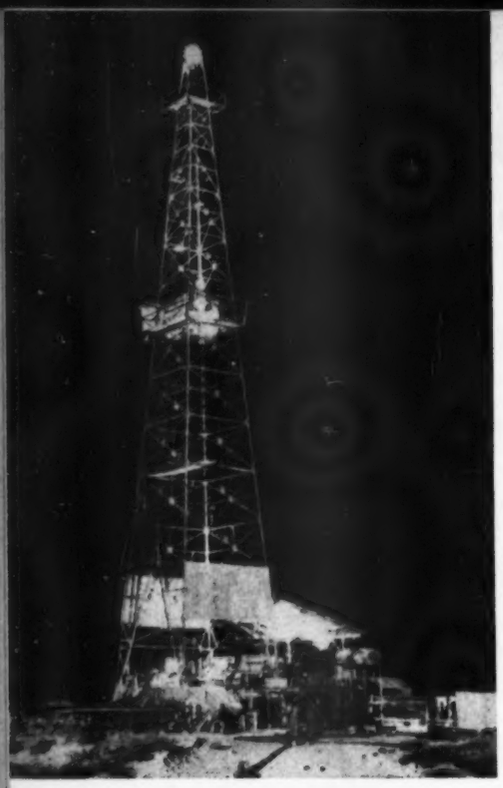

Sui No. 1 lit by gas flare.

Pakistan Petroleum Opens Natural Gas Pool in Sui

A natural gas pool has been discovered in Sui, Dera Bugti of Baluchistan in the first well drilled there by Pakistan Petroleum, Ltd.

Announcing this find the prospecting company said that tests are now being made to determine the productivity of the gas accumulation.

The company announcement further stated that in order to determine the extent of the gas pool another well is about to be drilled in the same area.

Pakistan Petroleum began drilling the first test well in the arid Sui desert in October of 1951, and drilled the well to a final depth of 10,049 ft in July of this year.

Production tests have been made at various levels in the well without finding any oil.

Mississippi Field Opened

Barnett Serio and Norman Germany have run potential tests at their pool opener, No. 1 Thaddeus Leak, in Wilkinson County, Mississippi. The new well, which opened the Commencement field, is pumping at the rate of 96 bbl of oil per day plus 8 per cent wash water. Gravity of the oil is 39.8 deg, with gas oil ratio 200 to 1. Flow is from casing perforations opposite the Walker sand of Wilcox at 6545-50 ft.

Kansas Wildcat Complete

Skelly Oil Company has reported completion of a new wildcat gas well in Meade County, Kansas. It is the company's No. 1 Sheetz, which had an open flow test of more than 8,700,000 cu ft of gas. It is producing in the Mississippian from 5778 to 5795 ft, and is situated about 2 miles from the McKinney field.

Carter Gas Well Flowing 6,000,000 Cu Ft Gas a Day

Carter Oil Company has an apparently new gas well with a flow of 6,000,000 cu ft a day. It is the No. 1 Moss, in Carter County, Oklahoma, which flowed 6,000,000 cu ft of gas a day between 3421-84 ft, and the same amount on a second test between 3460-84 ft.

Sinclair Has Large Well

Sinclair Oil and Gas Company et al have completed the No. 1 Willie Smith Community in McClain County, Oklahoma, for a flow of 1463 bbl of 45 gravity oil in 18 hr, 10 hr through a ½-in. choke and 8 hr through a ⅜-in. choke. Gas-oil ratio was 2446 to 1 with a flow of 4,470,000 cu ft a day.

Oil Search Set for Africa

An intensive search for oil will be made along 500 miles of the East African coast by Shell interests, Arthur Hope Jones, Kenya's member of commerce and industry, has revealed. Jones reported that Shell is expected to reach a final decision in January on whether to go ahead with plans for building a big refinery at Mombasa, but added that prospects for getting it were bright.

Canadian Gas Well

Anglo-Canadian Oil Company has made a new multi-zone gas discovery 50 miles north of Edmonton, Alberta. The well tested several recoveries at 2,500,000 to 2,800,000 cu ft daily in drillstem tests.

Hulldale Pool Extended

Sinclair Oil and Gas Company has extended the Hulldale Strawn reef lime pool of Schleicher County, Texas. Extension well is the No. 1 Dwight McClatchey, which showed gas at the surface in 3 min, mud in 18, and oil in 24 on a 2-hr drillstem test from 5625 to 5650 ft. Tested to tanks the last hour, it made 67 bbl of oil. Gas-oil ratio was 642-1. Final recovery was 1080 ft of oil, and then deepened to 5675 ft for completion.

MIT Geology Department Adds Geophysics Section

The department of geology at the Massachusetts Institute of Technology has been renamed the department of geology and geophysics to recognize increased emphasis on instruction and research in geophysics within the department. The department now offers two separate courses, one leading to the degree of bachelor of science in geology and the other to the degree of bachelor of science in geophysics. Either course satisfies the requirements for admission to the MIT Graduate School for work toward advanced degrees in geology, geophysics, and geochemistry.

An optional cooperative program in geophysical field training has also been arranged for the summer following the junior year with the Geophysical Service, Inc., of Dallas, Texas. The student participating in this program joins a field party engaged in seismic work.

West Texas Well Flows 967 Bbl Oil in 12 Hr

A new West Texas wildcat has been completed for a calculated 24-hr flowing potential of 1934 bbl of oil, plus 517 bbl of mud. It is Amerada Petroleum Corporation et al's No. 1 L. R. Weems in a Devonian discovery in Yoakum County. The potential was based on an actual 12-hr flow of 967 bbl of oil through a ¾-in. tubing choke and perforations between 11,773 and 11,850 ft. Gas oil ratio was 187-1.

Arkansas Test Successful

A new gas discovery well has been completed in Johnson County, Arkansas, by Pure Oil and Big Chief Drilling Company. It is the No. 4-A Low Gap, which tested 1,000,000 ft of gas a day from the Hale sand at 2352-92 ft, after a shot of nitro. Total depth of the well is 2537 ft, and is producing from the Pitkin lime.

New Zone Hit in West Texas

A fourth prospective pay zone has been uncovered in Andrews County, west Texas. The Devonian was topped at 10,730 ft at Shell Oil Company's No. 1-A-1 University, which showed free gas to surface in 35 min, and oil mist in 90 min on drillstem test. Recovery in the stem was 150 ft of gas-cut mud, 270 ft of oil and gas-cut mud, and 150 ft of oil cut with mud and gas. Bottom-hole flowing pressure was 300 lb. This well is projected to test the Ellenburger at 13,000 ft.

New Sand Hit on Gulf Coast

Western Natural Gas Company and Continental Oil have hit a new gas-distillate sand in Calhoun County, on the Texas Gulf Coast. The well is the No. 1 State Tract 49, which on a 4-hr production test, flowed at the rate of 2,043,000 cu ft of gas daily on a ¼-in. choke and approximately 100 bbl of 51 gravity distillate to 1,000,000 cu ft of gas. Flowing pressure was 2000 lb, and production is from an upper Frio sand.

Oil Found in Tunisia

Oil has been found 90 miles southwest of Tunis in the mountain area of Tunisia, French engineers have reported. Engineers for the Societe D'Etudes Pour les Recherches Petroliferes said some gas had been brought up but "it is much too early to say we have struck oil," Henry Mouly, director of the oil company reported. Raw oil, mixed with natural gas, is reported to have spurted from a steel derrick in a mountainside clearing outside the town of Kesra from 1800 ft down.

Olson Gets New Oil Pool

Olson Oil Company has opened a new oil pool with the reworking of a temporarily abandoned test in Logan County, Oklahoma. The well, the No. 1 W. Filtz, was abandoned temporarily last January at a depth of 6105 ft in the Second Wilcox sand. Olson plugged it back to 5940 ft and set casing at 5885 ft. It bailed and shot with 75 qt and then swabbed 3 bbl of oil an hour for 16 hr.

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Running Tour With Men in the Industry

Russell R. Simonson, Ohio Oil Company, has been named president of the American Association of Petroleum Geologists for 1953. Other officers for AAPG elected at the annual meeting of AAPG, Society of Exploration Geophysicists, and Society of Economic Paleontologists and Mineralogists, Pacific Sections, include: **Rufus M. Smith,** Continental Oil Company, vice president; **Robert G. Maynard,** Sunray Oil, secretary, and **Tom E. Folsom,** Honolulu Oil, treasurer.

SEG officers include: **Robert B. Galeski,** Honolulu Oil, president; **Carl Savit,** Western Geophysical Company, vice president, southern district; **William D. Cortright,** Tide Water, vice president, northern district, and **Robert J. Wells,** Richfield Oil, secretary-treasurer.

Orville L. Bandy, University of Southern California, geological department, was elected president of SEPM and **Dana B. Braislin, Jr.,** Union Oil, secretary-treasurer.

Glen V. Kersten, district engineer for Western Gulf Oil Company at Fruitvale field near Bakersfield, California, has been appointed superintendent of the company's South San Joaquin Valley area. Kersten joined Western Gulf Oil Company in 1943 as petroleum engineer, in 1946 he was transferred to Paloma field as production engineer and in 1948 was promoted to district engineer, Fruitvale field, the position he occupied until his recent promotion to superintendent of South San Joaquin Valley area. Kersten acquired a BS degree in petroleum engineering from the University of California at Berkeley. Prior to his association with Gulf, he was employed by The Texas Company, Pacific Gas and Electric Company, and Tidewater Associated Oil Company.

J. B. Wharton, district superintendent of Oak Canyon field, has been appointed executive assistant to the vice president, Western Gulf. Wharton who attended the University of California, joined Western Gulf in 1945 as field superintendent and was later made district superintendent of Oak Canyon field, the position he held until his latest appointment.

H. S. Brigham has been named manager of exploitation of California area for Western Gulf Oil. Brigham joined the company in 1943 as field superintendent of Oak Canyon operations. In 1948, he was promoted to district superintendent of Fruitvale district and continued in that capacity until his appointment as manager of exploitation. Brigham's experience in production matters have also been utilized by the Gulf Oil Corporation, who in 1951, sent him to South America on a special production assignment.

Joseph Neely has been promoted from district geologist at Midland, Texas, to senior staff geologist and transferred to Magnolia Petroleum Company's general offices in Dallas. **W. L. Moreman,** formerly district geologist at Oklahoma City, has been advanced to staff geologist and moved to the company's general offices in Dallas.

Albert Gregersen has been named executive assistant (area manager) in the New York foreign production division of the Gulf Oil Corporation and will continue to act as that department's governmental relations advisor, C. W. Hamilton, vice president in charge of foreign production, has announced. At the same time he said that **E. E. Ferrin** has been named technical advisor; **C. W. Flagler,** exploration advisor; **L. C. Sass,** assistant exploration advisor; and **Wolfe J. Frankl,** economic advisor.

Fred M. Clement, Denver, Colorado, and **Wayne E. Glenn,** Los Angeles, California, have been promoted to new production department positions with Continental Oil Company. Assistant production manager of Conoco's Rocky Mountain region, Clement has been promoted to production manager of the company's central region, with headquarters at Oklahoma City. Glenn, western region petroleum engineer for the past five years, has been named to succeed Clement at Denver.

Clement joined Continental in 1941 as a roustabout in the Jal, New Mexico area. He became a petroleum engineer in the Hobbs, New Mexico, district office the following year and was promoted to division petroleum engineer at Casper, Wyoming, in 1943. He transferred to Denver as region petroleum engineer in 1948 and was promoted to assistant production manager of the Rocky Mountain region later that year.

Fred M. Clement, left, is new Continental Oil production manager at Oklahoma City. Wayne E. Glenn will go to Denver as assistant production manager of Rocky Mountain region.

O. F. Sebesta, who has been with The Texas Company 14 years, has been promoted to general superintendent of drilling and production, West Texas division of Texaco's producing department.

H. F. Longren will succeed Sebesta as assistant district superintendent at Midland, Texas. Sebesta, who was born at Beeville, Texas, was graduated from Texas A. & M. College with a BS degree in petroleum engineering. He joined the company as a roustabout at Houma, Louisiana. He was made drilling foreman at Penwell, Texas, in 1948 and assistant district superintendent at Midland in 1949.

Longren holds a BS degree in petroleum engineering from the University of Texas. He became a petroleum engineer in 1947, and in 1948, he was named district petroleum engineer at Pampa.

Z. L. O'Byrne-Wyszynski has been named drilling superintendent with the Department of Rural Water Development, Government of Gold Coast, British West Africa.

Teddy Royce Hancock, a petroleum engineer in Magnolia Petroleum Company's Falfurrias, Texas, district, has been transferred to assistant production foreman in the same district.

James V. Barnes has joined the University of Texas staff as instructor in geology.

He taught last year at Washington University, St. Louis; and had previous teaching experience at Kansas City and Missouri Universities, and was employed by the U. S. Geological Survey for a year and a half.

R. L. Foree has announced that he is leaving the Petroleum Administration for Defense on January 1. Foree is director of production for PAD.

Dr. Ely Mencher, formerly senior field geologist and research geologist with the Socony Vacuum Oil Company of Venezuela, has been named associate professor of geology in the department of Geology and Geophysics at the Massachusetts Institute of Technology it was announced by Dr. George R. Harrison, Dean of Science at the Institute. At MIT. Dr. Mencher will conduct courses in stratigraphy and petroleum geology and will continue his research on the geology of South America.

Dr. Mencher received the degree of bachelor of science from the City College of the City of New York in 1934 and the degree of doctor of philosophy from the Massachusetts Institute of Technology in 1938.

Since 1943 he has held positions of increasing importance and responsibility with the Socony Vacuum Oil Company of Venezuela, including the posts of senior field geologist and of research geologist. He has carried on a varied program of field work and research in Venezuela, Colombia, and Puerto Rico.

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Two cones were completely sheared from the rock bit and one was bent in. The McCullough Double Acting Rotary Jar was still in excellent condition. The striking surfaces were not overly worn and the packing still provided a perfect seal. Had it been necessary, the McCullough Rotary Jar could have continued under this severe usage for many more hours.

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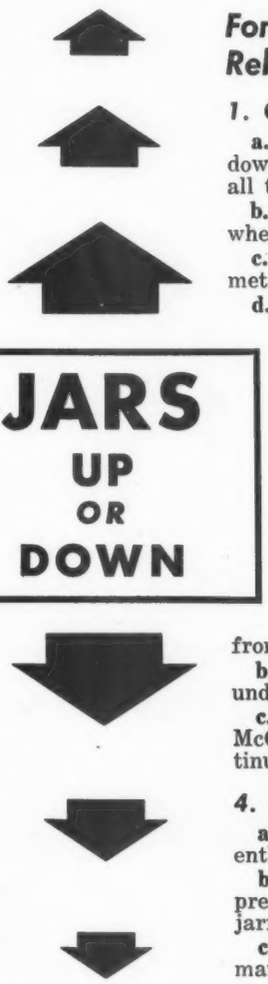

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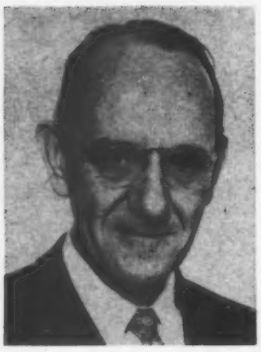
Running Tour

John T. Rouse

James C. Menefee

William W. Clawson



Philip H. Jennings

John W. Clark

John T. Rouse has been named manager of exploration and **James C. Menefee** chief geophysicist for the newly created exploration and producing organization of Socony-Vacuum Oil Company in the Williston Basin and northern portion of the Rocky Mountain states. The new organization is under the direction of **W. W. Clawson,** recently named general manager of the unit and formerly chief geologist of Magnolia, a Socony-Vacuum affiliate.

Rouse has been a staff geologist in Magnolia's general offices in Dallas and Menefee was formerly assistant director of geophysical exploration. They will be stationed at Casper, Wyoming, temporary headquarters of the new Socony-Vacuum unit.

At the same time it was announced that **Philip H. Jennings** has been promoted to assistant chief geologist of Magnolia succeeding **John W. Clark** who was advanced to chief geologist of the company.

Rouse received his bachelor's and master's degrees from the University of Cincinnati, and was then graduated from Princeton University with a Ph.D. degree in geology. After teaching at Hamilton College and Ohio State University for six years he joined Magnolia as a geologist in 1938.

Menefee was graduated from Louisiana State University in 1933 in geology. For the next five years he was engaged in geophysical work with oil companies in the Southwest and in eastern Venezuela. He joined Magnolia as a seismologist in 1939.

A staff geologist in Dallas for Magnolia for the past three years, Jennings was first graduated from Columbia University with an AB degree in geology in 1923. After working in several Texas oil fields as a roustabout, foreman and production engineer for the next seven years, he returned to Columbia in 1931 to study geology. He received his Ph.D. from there in 1936 and in the summer of that year joined Magnolia as a geologist in Shreveport, Louisiana.

F. W. (Dick) Borden has been named manager of the California district operations for Sunray Oil Corporation succeeding **R. E. Foss,** recently transferred to the company's general offices in Tulsa, Oklahoma, as vice president and manager of the company's exploitation department.

Borden joined the company in 1930 as a roustabout, working as pumper, gager, and field clerk in various California areas until 1933 when he became gasoline absorption operator. In 1948 he became production superintendent in charge of all the company's California operations and in May of 1952 was appointed general superintendent of the California district, succeeding Foss in that capacity when Foss was named general manager of the district succeeding W. C. Whaley, formerly of Los Angeles, who went to Tulsa as president of Sunray Oil Corporation at that time.

Borden is a graduate of the University of Nebraska college of engineering.

Hollis D. Hedberg has been named chief of the geology and geophysics section, land and exploration branch of the production department, Gulf Oil Corporation, and will supervise and direct staff activities in the fields of geology and geophysics in the Pittsburgh, Pennsylvania, office of the department.

Robert L. Boggs has been named assistant to the vice president, production department, and will assist Heald in the discharge of his executive duties. **H. J. Wharton** has been named chief exploitation engineer in the exploitation and engineering branch of the Pittsburgh headquarters of the department, where he will review, analyze, and process engineering programs, projects, and problems for executive consideration.

A. H. Stoecker has been named chief of the economics section in the fiscal branch of the department and will be engaged in economic studies relating to budgetary and financial programs of the department.

Hedberg joined Gulf in 1928. He was transferred to New York, from Venezuela, production department office, in 1946 and was appointed chief geologist and exploration advisor, and in 1951, was appointed manager of exploration and served in that capacity until his most recent promotion and transfer. Boggs joined Gulf in the Tulsa production division as a district engineer in 1927. Boggs was transferred from Venezuela to the New York office of the foreign production division in 1951, and was appointed manager of Western Hemisphere production operations, from which he was recently promoted.

Wharton joined Gulf in 1928. In 1951, he was appointed technical advisor and served in that capacity until his recent promotion. Stoecker joined Gulf in 1946 as assistant to the budget advisor in the New York foreign production division. Successively, he has held the positions of assistant to the vice president and economics advisor in the foreign production division and was serving in the latter capacity when transferred to Pittsburgh.

Houston Nomad Barbecue. Instead of the regular monthly meeting, the Houston, Texas, chapter of Nomads held a barbecue at the Texaco Country Club recently. Attending the dinner were Jack A. Barnes, Trinity Portland Cement, barbecue and tournament chairman; M. G. Erhard, International Petroleum, Talara, Peru, and Ing. Ivan Carvalho, Brazilian Government Oilfields, Bahia, Brazil.

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Owens-Illinois
Glass Company

C. J. Kuhasz
M. W. Kellogg
Company

E. Rose
Born Engineering
Company

Clyde Berg
Union Oil
Company

W. L. Martin
Humble Oil
Company

C. B. Barry
Blaw-Knox Chemical
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Mechanical Engineers Implement Oil Industry

Chemical and mechanical engineers discuss developments and methods important to the refiner and his problems

ARCH L. FOSTER*

NOTHING illustrates better the complete dependence of the oil refining industry on two groups of technologist-engineer personnel—the chemist-chemical engineer group and the mechanical engineer group—than the recent meetings of the American Chemical Society and the Society of Mechanical Engineers. It is trite and grammar-schoolish to remark that the chemist supplies the processes by which oil is refined, while the mechanical engineer builds the equipment by and in which these processes are carried out.

This essentially Siamese-Twins combination in less than a generation has raised refining from a rather poorly managed cut-and-try, apprentice-caliber art to one of the most exact and exacting of sciences. The result has been the metamorphosis of this industry from a kitchen-stove guild to a chemical industry. It is no stretch of imagination to see that the manufacture of present-day motor or aviation fuel is as much a chemical operation as is the synthesis of liquid hydrocarbons from methane.

At Kansas City the mechanicals discussed in careful detail a great number of subjects important to refiners and their problems. Among these are the production of ammonium sulfate (fertilizer) from refinery acid wastes; methods and economics of natural gasoline production lease-side; thermal insulation of refinery equipment; several phases of the oil-shale industry, direct-fired heaters, structure fire-proofing, innumerable ways for maintaining refinery equipment, and divers other important considerations.

Coincidental with the enforcement of No-Flare gas regulations in various states has come the development of the "packaged gasoline plant," which can be moved in toto into or out of a field to process relatively small quantities of gas for conservation of resources and increase of total revenue. As an example of costs and payout requirements, C. B. Barry of Blaw-Knox's chemical plants division stated that a unit producing 3000 gal of natural gasoline per day should have operating expenses of the order of $7000 per year to pay out in three years after all charges are deducted. Barry described a typical packaged unit as designed to process 5,000,000 cu ft of raw gas daily, at 150 psig, to recover 90 per cent of pentanes in the gas. This unit has no steam generation facilities, uses direct-fired heaters, and the main processing items are skid-mounted together, with auxiliaries such as cooling tower, heater, and power generating units on separate skids. Such a unit requires 9.2 kw for pumps, 3.0 kw for plant lighting, 23.4 brake horsepower for recycle compressor power, 39,000 cu ft per day of heater fuel gas, with 100 bbl of cooling tower water makeup daily. Dry distillation is the main item to reduce plant cost, a maximum of 550 F temperature is held on the heater to avoid cracking absorption oil, the plant instruments operate on gas pressure, and the whole unit and its operations are simplified and made automatic, to enable lease men, unacquainted with the fine points of plant operation, to supervise the plant successfully.

A plant of this general type of operation will pay out satisfactorily, as was indicated by Wickliffe Skinner of Black, Sivalls and Bryson, discussing the economics involved. Using only low temperature separation and stage separation processing, making 31.1 bbl of stock tank oil, valued at $2.75 per bbl, a unit costing $41,000 will pay out in 320 days or a short year, Skinner showed. With low temperature separation and gasoline recovery the same capacity unit will cost $47,500, make 2080 gal of gasoline, and pay out in 169 days. Added to this the recovery of 2120 gal of LPG daily, the unit costs $61,000 and will pay out in 139 days, with gasoline priced at 9.0 cents per gal and LPG at 5 cents.

New Insulation Techniques

By the adoption of materials developed recently for insulating industrial equipment, and by utilizing prefabrication of many shapes wherever practicable far-reaching advances have been made in thermal insulation in cost, installation speed, efficiency, and insulation life. Outlining these developments

*Editor, Refining and Gas Processing.

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under study and experiment for some three years, C. J. Kuhasz, M. W. Kellogg Company, and E. C. Shuman, research director for Kaylo Division, Owens-Illinois Glass Company, discussed in detail the preparation, installation, and advantages of the new insulating system. Determining that hydrous calcium silicate is probably the best material for the insulation system planned, the method was developed with care. Early jobs indicated that as much as $50,000 was saved on installations costing originally $250,000.

The method can be used for all metal temperatures up to 1200 F, in a single thickness. The material itself has a density of about 11 lb per cubic foot and a compressive strength of about 150 psi, is incombustible and comes in 1-in. to 5-in. thicknesses, by ½-in. increments, in flat and curved block and pipe shapes. For regularly curved or shaped surfaces the blocks are preformed to fit; for irregular curved surfaces blocks are made by fastening woven glass fabric to small triangular blocks that can be arranged to fit the surfaces.

The outside of the insulation is weathercoated before installation. Insulation of outside diameter greater than 16 in. is reinforced with a layer of glass fabric. Equipment required for field applications includes weld guns and welding generators, compressed air spray equipment, electric hand drills and canvas or rubber gloves.

In a companion type of development, the use of shop-fabricated sections of concrete along with new application methods, as developed by Kellogg engineers, it has become practicable to protect steel support and framework members of industrial units from fire attack at reduced cost. The concrete is so fabricated as to weigh only 40 per cent as much as regular concrete and is made in two shapes, 90-deg ells and flats of various dimensions. These sections are cast to required dimensions in adjustable metal pans, from mixtures of perlite aggregate and air-entrained portland cement; all are reinforced with welded wire mesh. The material so formed can be worked by most common tools, units can be handled manually rather than to require power hoists. The installations have been tested according to Underwriters Laboratories standard tests with satisfactory results. Comparison of relative costs shows that the total cost of insulating 4800 sq ft of surface by the prefabricated method described is $7555. For pouring concrete to cover the same surfaces the cost is $11,163. In addition the saving in foundations, structural steel, etc., by the block method is some 168,000 lb deadweight.

An entirely different set of conditions and requirements are met in supplying low-temperature insulation, according to W. L. Thomas of Humble Oil and Refining Company's mechanical engineer division. Insulation's most important property is heat conductivity and all properties must work toward that efficient end. Water absorption and water vapor permeability are two very important properties, and penetration of water as vapor or liquid into insulation reduces rapidly the efficiency of the material. An insulant for any job must be selected in terms of the conditions to be met. Insulation in a location where for any reason temperatures of 250 F, or 800 F or any other temperature will be experienced must withstand the temperatures expected. Units undergoing off-and-on operations involving a wide temperature variation must be insulated with material that will function without breakdown over the entire range, repeatedly and long life periods. Insulation exposed to water vapor or liquid must be impervious to the entrance of water in any form. Maintenance of insulation once applied in service must be immediate and continuous, to repair damages before each instance has become serious.

Maintenance a Major Service

"The goal of all refinery maintenance is to maintain operating equipment so that only scheduled shutdowns will occur and so that shutdowns may be scheduled farther apart," is the code of the refinery maintenance department stated by C. H. Trotter of Phillips Petroleum Company. Basic factors that promote an efficient program include careful planning, personnel education and training, preventive maintenance, improvement of equipment and methods. The backbone of preventive maintenance is a card-filing system for pertinent information on all types of equipment needed to follow maintenance routines, including maintenance records of the individual unit, which removes the responsibility from the memory of some employee. Efficient preventive maintenance plans ensure longer equipment life, higher production and better manpower utilization. A trained staff organization for planning and scheduling of maintenance work day-by-day is more efficient, takes excess work and responsibility off line supervisors and applies the analysis and planning principles to routine work that are used in preparing for major turnarounds. One of the greatest problems that pays off best is personnel training, by way of visual aids, lectures, and schools in which company and outside instructors function to train all members in their duties.

A system of periodic inspections of operating equipment involves the greatest amount of work and also brings the greatest returns, say J. O. Thoen and L. G. Foster of Continental Oil Company's maintenance department. Careful study and more careful planning are required to make the inspection system really efficient. The scope and frequency of inspections must be held to the minimum in order to reduce costs, loss of operating time, and the amount of ineffective labor used. Inspections must be scheduled and planned so that no part of the system can be omitted without danger of high maintenance costs. Especially in corrosion prevention is the technical staff important. Application of continuous studies and experiments in corrosion and metallurgical engineering is necessary to efficient operation and it may be assumed that a possible or actual preventive measure to meet every maintenance problem exists and by proper study and analysis the technologist has a good chance to solve the problem in each case.

Detergents for Chickens

Roosters and hens may soon look to petroleum for their well-being. Experiments indicate that detergents — similar to washing powders — may be added to chick rations to give the boost in growth that antibiotics do. Basic chemicals that go into most detergents are oil-derived.

Ammonium Sulfate from Plant Waste

Many refiners have considerable amounts of acid sludge to dispose of, along with other wastes, including those containing ammonia from various streams or from commercially pure ammonia purchased for neutralization of sludge. In a process described by E. D. Fox of Fluor Corporation, General Petroleum Corporation of Torrance, California, collects acid sludge (H_2SO_4) from stove oil, diesel oil, gasoline, and other streams treated in a common tank, is mixed with sour stripping steam and the ammonia component are passed into the reactor. The ammonia in this unit derives from a stripper unit where refinery waste streams are stripped of hydrogen sulfide and ammonia before final disposal. Acid and ammonia react to form ammonium sulfate, which comes off overhead along with recycled "mother liquor" and sludge oil and from which it is separated by gravity settling. The sulfate is recovered by crystallization by evaporative cooling (a Struthers-Wells unit), and filtration, and dried as a commercial product. Elementary sulfur is recovered from the hydrogen sulfide in the overhead vapors from the reactor, in a Claus type sulfur recovery unit.

Based on 95 per cent acid recovery, and 2500 lb of sulfate per ton of waste acid, the recovered ammonium sulfate is worth about $45 per ton. The sludge oil is recovered for fuel oil "as is," while the solid sulfur is another product the refiner can sell profitably. If by-product ammonia is not available, then commercial ammonia must be used which, at $75 per ton makes the 515 lb needed per ton of finished sulfate cost about $19. Because certain properties such as crystal size are of critical importance, it is suggested that a test (pilot plant) run be made on the specific sludge under study to determine the operating results in each case.

Reporting several phases of the oil shale program, Bureau of Mines showed details of design of several retorting units, the rectangular-cell retort, round-cell units, and others. At present the rectangular-cell appears to have the advantage over other designs, but further work is being done on designing round-cells, to eliminate if possible some of its disadvantages. * * *

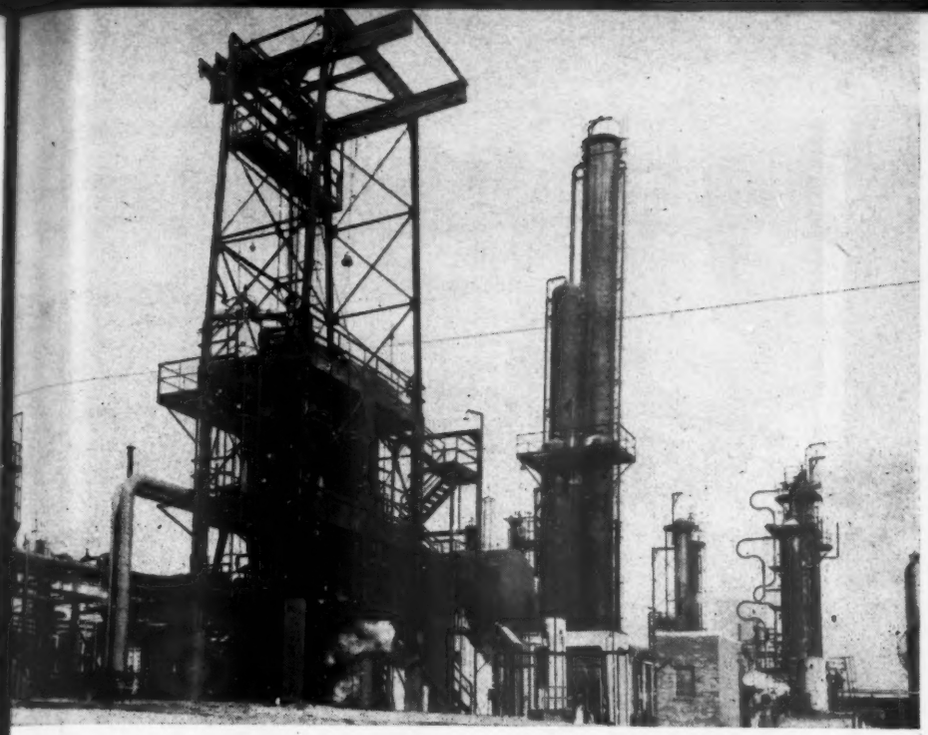

FIG. 1. Treater, left, contactors, and fractionating towers of the plant.

HF Alkylation Unit Revamp Contributes to Scrap Drive

H. K. WHEELER, JR. and R. H. JUDICE

THE El Dorado refinery of the Pan-Am Southern Corporation recently placed back in operation their HF alkylation unit that had been shut down in 1946 following the termination of World War II. The alkylation unit was completely revamped with the elimination of considerable equipment, including pipes, valves, and fittings, following intensive design engineering studies. It is estimated that 20 tons of scrap were removed from the unit during the revamp.

During the early part of 1942, the El Dorado refinery of the Root Petroleum Company (Pan-Am Southern Corporation) was awarded a defense plant contract that included the construction of aviation gasoline manufacturing facilities. This construction included the installation of a 4500-bbl per day fluid catalytic cracking unit and associated facilities, and an HF alkylation unit capable of producing 1100 bbl per day of light alkylate. The HF alkylation unit (Fig. 1) was of standard UOP design and was installed for the purpose of processing refinery propanes and butanes for the production of a base stock suitable for blending into Grade 100-130 aviation gasoline. The alkylation plant was completed in early 1944, and up to the time of its shutdown in 1946 produced 604,400 bbl of net aviation alkylate. Because of a shortage of isobutane a butane isomerization unit was also included in the DPC contract, and a Girbotol and regenerative caustic treater were installed to sweeten the propane-butane stream to the alkylation plant.

Following World War II the HF alkylation plant at El Dorado was shut down. The alternative to shutting down the alkylation plant was the polymerization of refinery propanes and butanes, and economic studies indicated that it was much more economical to revamp the butane isomerization unit into a phosphoric acid polymerization plant rather than continue alkylation operations. In addition, refinery vapor pressure control was much simpler under this expedient as no outside butanes were required. Accordingly the butane isomerization unit was converted to a two-reactor catalytic polymerization unit, with the idle alkylation unit debutanizer tower being employed as a polymer gasoline stabilizer. The new catalytic polymerization unit was designed to process the total refinery propane-butane streams and had a design capacity of 2000 bbl per day. The treating facilities for the light end materials installed by DPC were capable of sweetening this total charge stock.

In late 1949, the Pan American Petroleum Corporation was merged with the Root Petroleum Company to form Pan-Am Southern Corporation, and at that time a considerable expansion program of the El Dorado refinery was initiated. During the short period of two years the crude capacity of the El Dorado refinery was increased from 20,000 to 30,000 bbl per day, and a new delayed coking unit and a fluid catalytic cracking unit were also installed. This rapid expansion presented problems associated with the light ends processing scheme, and studies were made to determine whether the polymerization unit should be expanded to handle the total refinery propane-butane stream, which now amounted to almost 3500 bbl per day, or if it would be more economical to rehabilitate the HF alkylation plant, processing the propanes on the existing polymerization unit and the butanes on the revamped HF alkylation unit. In both cases additional treating facilities would be required. This study indicated the revamp of the HF alkylation unit to be the more attractive expedient, and plans were initiated in early 1950 to rehabilitate this plant at the El Dorado refinery. The alkylation alternate study included the consideration of revamping the El Dorado HF alkylation plant to a sulfuric acid alkylation plant. This alternate had few advantages and several disadvantages of an extreme nature. To consider sulfuric acid alkylation at El Dorado would require the importation of large quantities of sulfuric acid per day, as no acid of this type was being used in the refinery. In addition, to eliminate the necessity of constructing an acid concentration plant in addition to the plant revamp, a market for the spent sulfuric acid would be required. This market was not readily available and shortages of sulfur were already being experienced. These two factors essentially eliminated sulfuric acid alkylation from consideration. In addition, the revamping of the HF plant to sulfuric acid operation would have required considerably more capital. Construction schedules called for this revamp to be completed prior to the startup of the second catalytic cracking unit in March, 1951.

It was recognized at the time of this

The Authors

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R. H. Judice is now associated with Diamond Alkali Company at Pasadena, Texas. He was formerly process engineer for the alkylation unit at the El Dorado refinery, and had been associated with Pan-Am Southern Corporation since 1950. Previously to that time he was with Humble Oil Company. Judice graduated from Louisiana State University in 1948.

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FIG. 2. Note lack of complicated equipment at base of contactors resulting from removal of mixers. Acid circulating pump is in background.

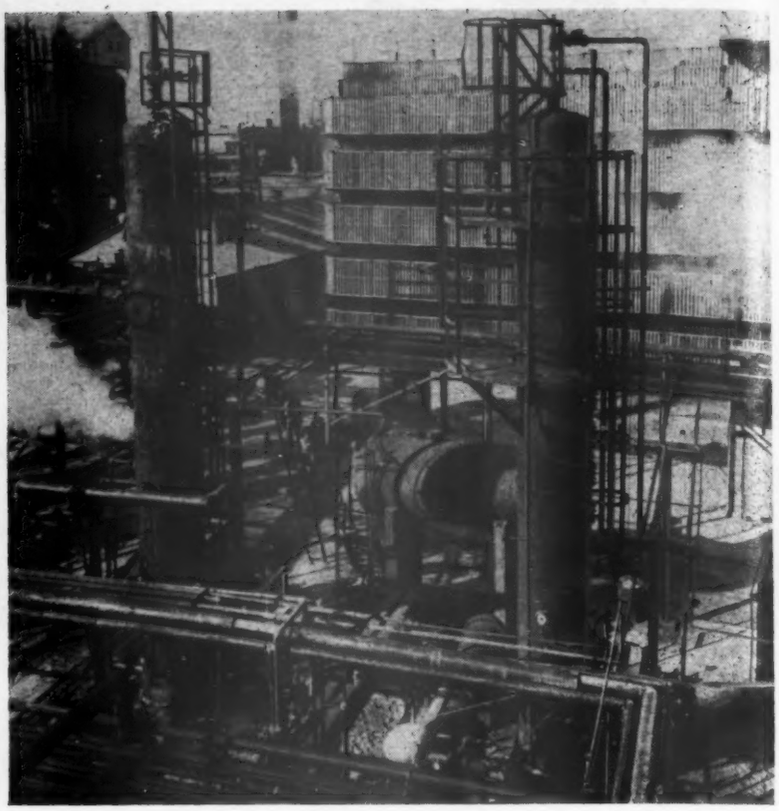


FIG. 3. General view of treater with scrubber on the left and caustic regenerator on the right.

decision to revamp the HF alkylation plant that many improvements in HF alkylation operations had undoubtedly come to pass during the period 1946-1950, when the El Dorado unit was shut down. The engineering and operating information obtained as a result of a thorough investigation of improvement in HF alkylation since 1946 led to innumerable changes in the design of El Dorado's HF alkylation plant. Basically the changes fell into one of the following major catagories:

1. Operating experience seemed to indicate that it was not necessary to agitate the HF alkylation reactor with the mixer provided for that purpose if the HF catalyst were made the continuous phase. If the butane charge stock were bubbled up through a continuous HF acid phase, neither conversion nor quality were apparently affected. This innovation eliminated the mixers on both El Dorado reactors reducing considerably the steam consumption on the plant and the troubles associated with the maintenance of these mixers and the prevention of HF leakage.

2. A serious problem when handling HF is the apparent freezing of spare rotating equipment during its idleness, and leakage of HF acid from valves necessary for the tie-in of this spare equipment. In order to minimize points of HF leakage all spare equipment in HF acid service was eliminated and all valves not necessary for the day-to-day operation of the unit omitted. To maintain the insurance provided by spare pumping equipment, however, complete spare pump rotating assemblies are maintained in warehouse stock so that, in case of a pump failure, little downtime results.

3. Again, to reduce points of HF leakage, control valves were moved from HF process lines to the corresponding utility line. The control of the plant under this system has been satisfactory and the troubles associated with control valves in HF service have been eliminated.

4. The regeneration of spent acid was confined to one tower where both acid concentration through water removal and the elimination of diluent tars is accomplished.

It will be noted that all changes to the HF alkylation plant at El Dorado were designed for one purpose — to reduce HF leakage with the resulting hazard and operation expense. During the period 1944 to 1946, the El Dorado plant consumed approximately 1.2 lb of acid per barrel of net light alkylate. In this respect the revamped plant has an acid consumption record of one pound per barrel of net light alkylate. Coupled with the improvement in acid consumption is the increased operating factor on the unit—93.5 per cent for present operation compared to 85.8 per cent for the period 1944-1946. In addition, acid burns have been much reduced averaging two per year during the current operations as against five per year during the previous operation. From these facts it can be seen that the purpose of the revamp was carried out very effectively.

Process Description

The nucleus of the El Dorado HF alkylation plant is two Stratco B size alkylation contactors. In these contactors the isobutane is reacted with butylenes in the presence of an HF acid catalyst to produce alkylate. The contactors on the El Dorado unit are cooled by the circulation of plant cooling water and the normal reaction temperature is about 100 F. These contactors were equipped originally with 250 hp mixers. Development work by others, however, indicated that if the contactors were filled with acid and the isobutane and butylenes dispersed in this phase, the reaction progressed without the necessity of mixing. This change has been made on the El Dorado plant (Fig. 2) and operations to date have indicated no disability in either yield or product quality. The B-B feed to the contactors is treated in a regenerative caustic treater (Fig. 3) constructed by the refinery force during the revamp, and the treated feed fed to the contactors through three 2 by 14 ft regenerative dryers. It is necessary for the process that the feed contain no water, in that water dilutes the acid catalyst and reduces its effectiveness. and in addition, the resulting dilute acid aggravates corrosion problems. The dryers are charged with florite and are regenerated about once a shift by the circulation of hot isobutane. The B-B feed is admitted to the contactors through a spider located in the bottom section of the contactor. Recycle isobutane is also admitted through this distributing device. The hydrocarbon phase then bubbles up through the contactors, which are operated in series on isobutane and in parallel on butylenes to maximize isobutane to olefin ratio. Any acid carry-

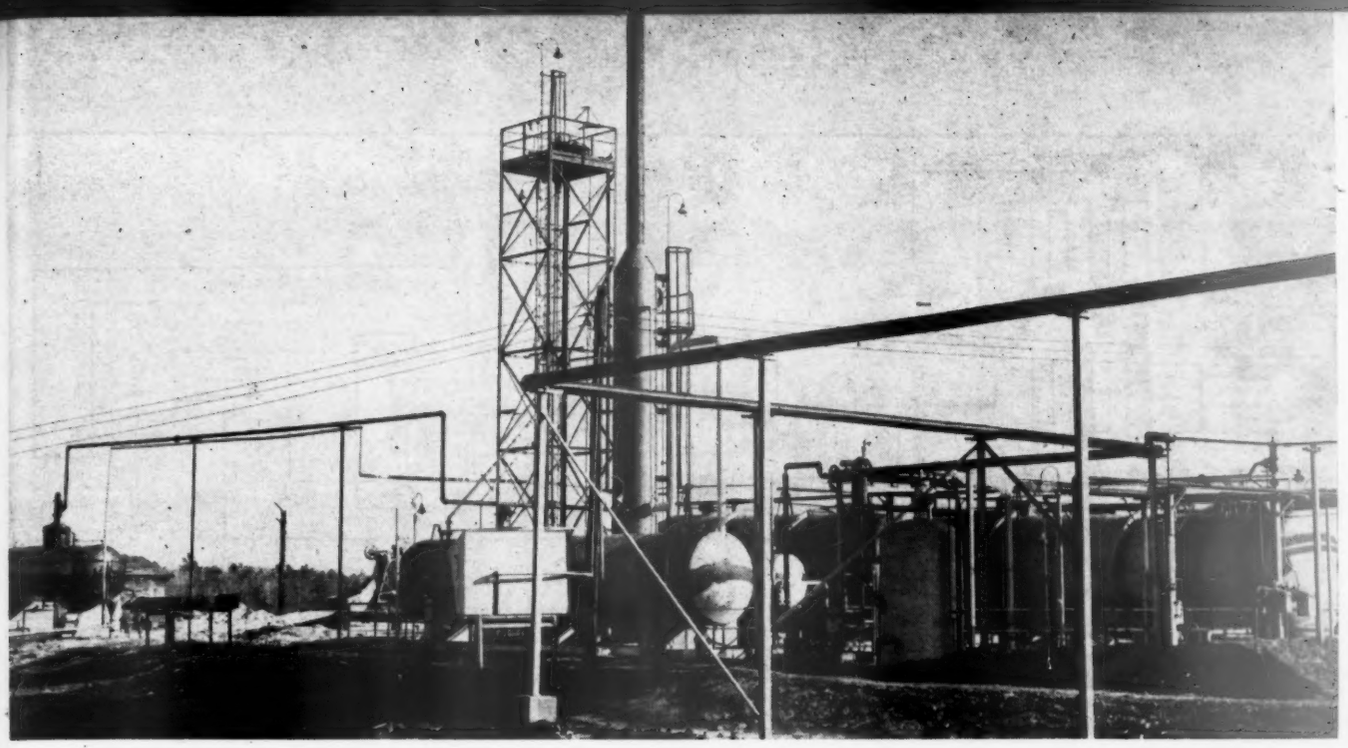


FIG. 4. General view of acid regeneration area. Note simplicity of layout and piping runs.

over is settled from the contactor hydrocarbon effluent in a 9½ by 40 ft settler. The settled acid is returned from the settler to the bottom of the contactor with a portion of this main stream diverted to the acid regeneration column to remove water and diluent tars.

The spent acid to the acid regeneration column flows through a steam preheater. Amount of preheat is determined by a temperature device controlling the steam to the preheater. The flow of acid to the acid regeneration column is not metered directly, but is calculated by the quantity of steam to the steam preheater. Preheated isobutane from the deisobutanizer is employed to strip the acid from the diluent tar-water mixture, and the heater control on this stream is identical to that described above for the acid. The isobutane for stripping is slightly acid, and hence this simplified control system. The stripped acid and isobutane are then condensed and returned to the acid settler. To regenerate the acid a top temperature of at least 200 F is required in the acid regeneration column. The simplified acid regeneration section is shown in detail in Fig. 4. Fresh acid makeup to the plant is added direct to the contactors.

The hydrocarbon phase from the acid settler flows to a surge drum where the acid hydrocarbon is charged to a depropanizer tower operating at about 260 pounds. In this tower any propane contained in the feed, plus unsettled acid, are removed from the butanes. The propane-acid mixture taken overhead in this tower is then stripped in an acid stripper and the HF acid returned to the depropanizer condenser. The propane bottoms from the acid stripper pass through a neutralization pot and are then directed to the refinery fuel system. HF acid accumulated in the depropanizer receiver is pressured back to the acid settler. The pressure control on the depropanizer tower is on the cooling water from the depropanizer condenser. In the original plant this control valve was on the depropanizer vapor line and maintenance problems, along with HF leakage, dictated changing this control to the cooling water system. The bottoms from the depropanizer tower is fed to the deisobutanizer. In the original plant this bottoms stream passed through bauxite towers and the only acid tower in the plant was the depropanizer. Removing the HF acid with bauxite on the total stream, including the isobutane recycle, however, presented many problems and the revamped El Dorado plant now operates the deisobutanizer as an acid tower. The isobutane recycle is taken overhead in this tower and any isobutane to storage is made completely acid free by passing through two 2 by 14 ft bauxite towers operated in series. The bottoms from the deisobutanizer pass through two 4½ by 30 ft bauxite towers in series through a caustic wash system into the debutanizer tower. The caustic wash system on the El Dorado plant was installed during the revamp and is designed to prevent the migration of silicon tetrafluoride to the debutanizer, where trouble with plugging of towers and condensers due to this compound had been experienced during the war-time operation. On the caustic wash system approximately four gallons of caustic are circulated for each barrel of hydrocarbon charge. The caustic is discarded when the silica content reaches 300 grains per gallon. The HF-free hydrocarbon is then debutanized and flows to the alkylate rerun tower where light aviation alkylate is taken overhead and the heavy alkylate as bottoms passes to storage. A flow diagram of Pan-Am Southern's revamped HF alkylation unit is shown in Fig. 5, and points out clearly the changes mentioned above.

TABLE 1. Operating conditions and laboratory inspections.
HF Alkylation Unit

Operating Conditions	
Reactor temperature, °F	97-102
Catalyst, Wt. % HF	85-90
Wt. % H_2O	0.5-2.0
Isobutane Olefin ratio	10-15
Acid consumption, lb per bbl light alkylate	1.0
Light Alkylate Inspections	
Reid vapor pressure, psi	7.0
Gravity, °API	73
Distillation	
10%	162
50%	217
90%	233
EP	320
Octane numbers,	
F-1, clear	93
F-2, clear	91
Performance numbers	
F-3+4.6 cc	125-130
F-4+4.6 cc	140-145

The El Dorado alkylation plant processes all refinery butanes except a small quantity of isobutylene employed in the manufacture of petrochemicals. This butane stream amounts to approximately 2500 bbl per day, and is separated from the refinery propanes in a 4 ft 6 in. depropanizer at the refinery gas concentration unit. The butane stream is then charged to the regenerative caustic treater and finally stored in a 5000-bbl sphere. The alkylation plant charge pump takes suction from this sphere and charges the treated butane feed to the dryers. It is necessary to purchase about 200 bbl per day of isobutane to balance this operation. Six vertical pressure storage tanks having a capacity of 5000 bbl are used to store this material. The light alkylate produced is stored in two 2500-bbl cone roof tanks from which it is shipped for aviation gasoline blending.

The El Dorado alkylation plant is currently processing about 2500 bbl per day of a refinery B-B stream. The reactors on the El Dorado plant operate at about 100 deg, and under these conditions aviation alkylate in the quantity of about 1500 bbl per day is produced. The quality of this alkylate is suitable for direct inclusion in Grade 100-130 aviation gasoline. A summary of process conditions along with product quality is given in Table 1.

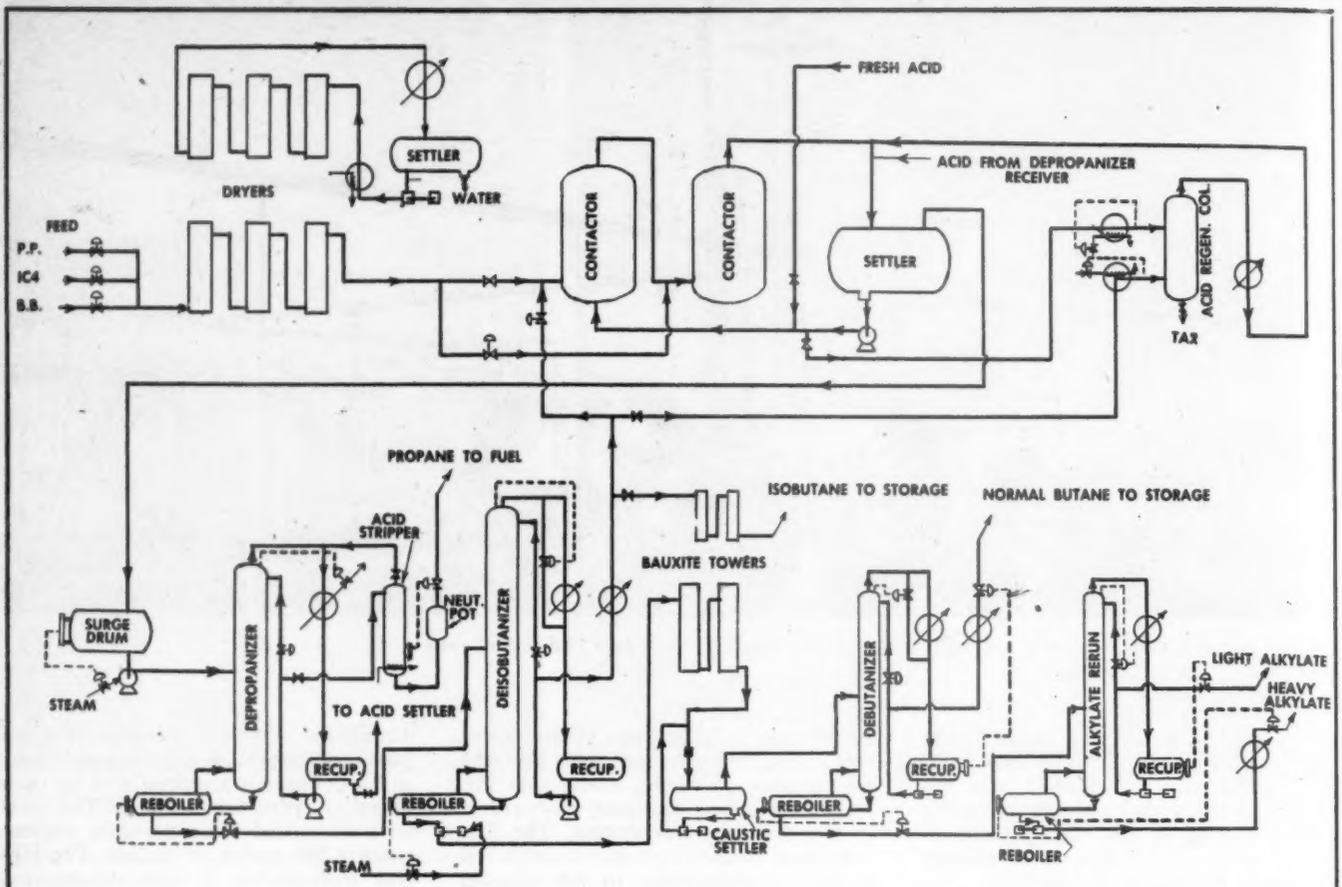
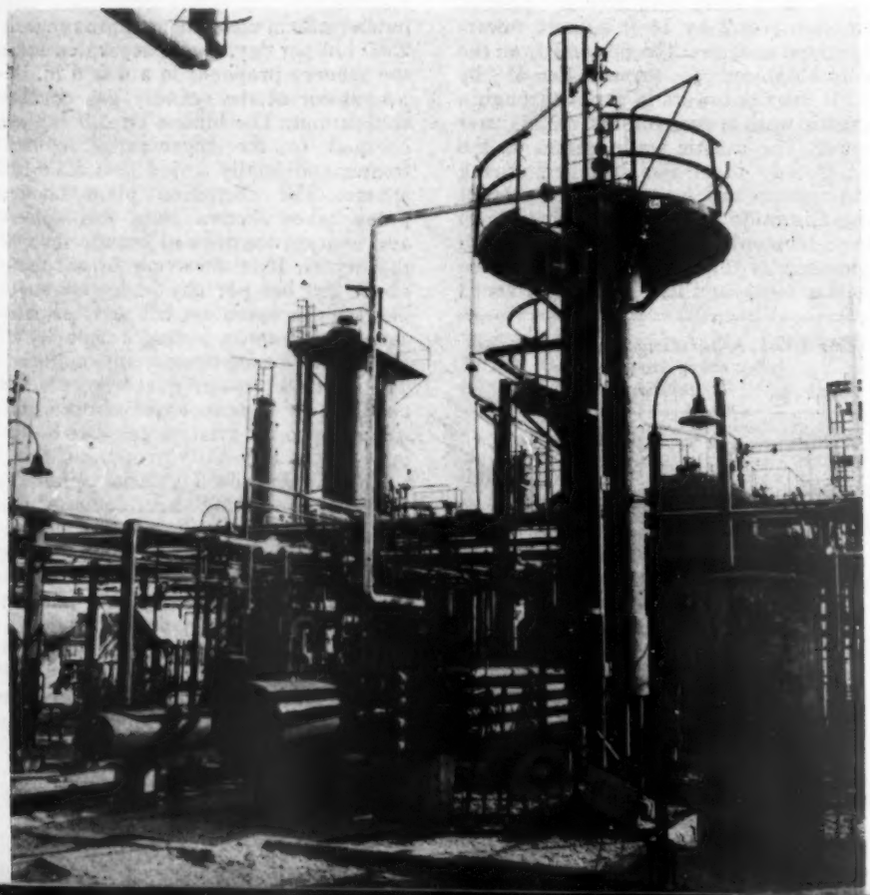


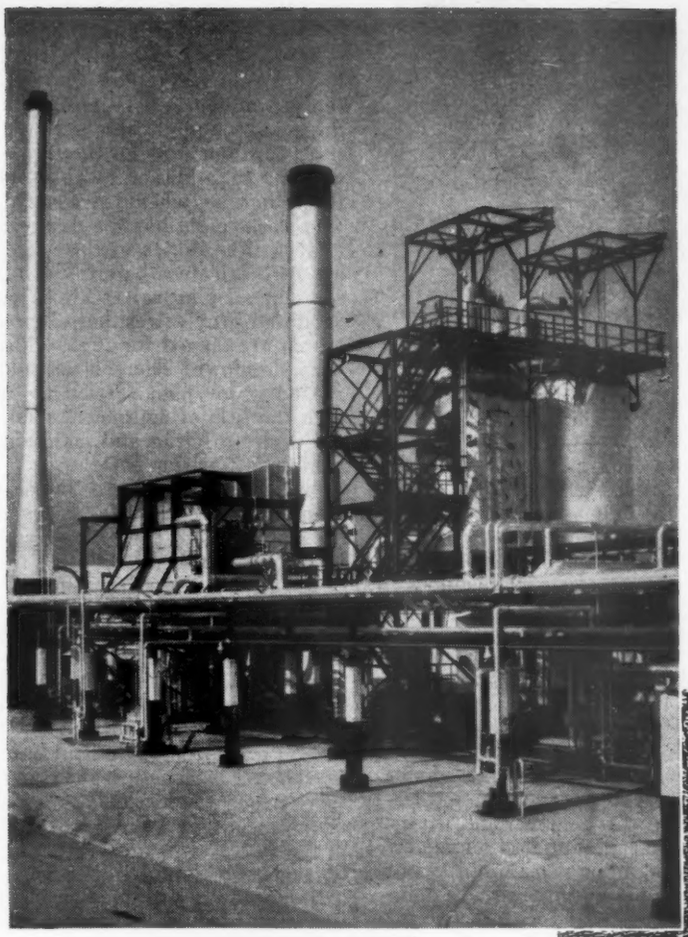
FIG. 5. Flow diagram of Pan Am Southern Corporation's HF alkylation unit.

FIG. 6. General view of blowdown area showing on extreme left tank car employed for neutralizing acid tar, associated stack and reagent tank in foreground, blowdown drum and acid drum in background.



Auxiliary Equipment

In any operation where a material as hazardous as HF acid is employed, the blowdown and acid storage area is of particular interest. On the El Dorado HF alkylation plant the acid storage and blowdown area is located approximately 300 ft from the alkylation plant in a relatively isolated area. The blowdown area is shown in Fig. 6. Note the tankcar body on the left for disposal of acid tar. The plant proper is connected to the blowdown area by four major lines; a relief valve header, a blowdown line and associated header, an exhauster line, and an acid and blowdown return line. In the blowdown area there are four main vessels, an 11 ft by 60 ft blowdown drum, a 9½ by 39 ft fresh acid storage drum, and a 7 by 40 ft reagent tank. The fourth major vessel is a vertical reagent scrubber into which the acid drums are vented and into which the exhaust header discharges. All these vessels are placed in a pit approximately 6 ft deep so that any acid spillage will be confined to the area. The floor of the pit is covered with one to two inch limestone in a layer approximately 6-in. thick to assist in the neutralization of acid spills. The reagent tank contains potassium hydroxide, which absorbs HF acid from the vented streams in the scrubber. The spent reagent is regenerated in a regeneration



PERCO*

CYCLOVERSION* AT MEXICO CITY, MEXICO

PEMEX started up this Cycloversion Unit on July 1, 1952. It has a capacity of 12,000 barrels a day. Plans are now under way to increase the capacity to 20,000 barrels a day.

At present, the unit is being used for catalytic desulfurization of straight-run and thermal cracked gasolines. As a result, PEMEX has been able to improve the quality of their regular grade gasoline and increase the quantity of the premium grade. In addition, during the first month of Cycloversion operation, the TEL requirements for this refinery's gasoline production were 74,000 pounds less than for the preceding month.

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pit adjacent to this area where lime is added to the potassium hydroxide. The regenerated KOH is returned to the reagent tank and the calcium fluoride produced in the regeneration is sent to the dump. In addition, the acid tar produced as the bottoms product from the acid regeneration column flows to this area into a 6500-gal tankcar body vented to the scrubber. The tar is bubbled through a layer of potassium hydroxide maintained in the tankcar and the neutralized tar then is stored in a vertical tank from which it is eventually used as a supplementary fuel in the refinery boiler house. To determine levels in the acid storage drum and the blowdown drum, a cylindrical monel float, containing a permanent magnet is employed. A compass is employed to locate the float, and the drum level. The float rises and falls in an external stainless steel float case. All relief valves on vessels containing even a trace of HF vent to the blowdown area, first into a knockout drum 4½ by 10 ft and then into the scrubber. The relief valves in HF service are protected from the acid by a monel explosion disc immediately below the relief valve. In the blowdown area there are two pumps, one for circulating the potassium hydroxide reagent, the other for returning blowdown from the blowdown area and also for charging fresh acid to the reactor system. As has been the policy in the rest of the plant no spare pumps are employed in this service and valves have been minimized to eliminate points of acid leakage.

Mechanical Features

On the El Dorado HF alkylation plant all pumps handling acid or acid hydrocarbon mixtures are not spared, with one exception. Because of the complications that would arise without the operation of the deisobutanizer reflux pump this pump has a spare. If this pump failed, without a spare there would be no way to remove acid from the alkylate, and a complete shutdown of the plant would be necessary with the possibility of acid carrying over to the debutanizer tower. The other centrifugal pumps handling acid are the acid circulating pump, the depropanizer charge pump, the depropanizer reflux pump, and the blowdown and acid return pump. All these items contain monel rotating assemblies and are packed or employ a rotary mechanical seal. Spare monel rotating assemblies are carried in warehouse stock for these pumps so that in case of a failure minimum downtime will result. In makeup of these rotating assemblies all close fitting parts are coated with lead seal compound, as it has been found that this material resists acid attack and has lubricant properties that facilitates dismantling of the rotating assemblies. As a matter of interest this same compound was used exclusively in makeup of screwed piping on this unit. The original installation of these pumps contained packing or a double rotary mechanical seal along with the necessary seal oil storage tanks and pump. In addition, there is a flushing oil connection above the rotary mechanical seal. On the revamped plant several of these pumps have been fitted with a single rotary mechanical seal and the flushing oil system improved. The single seal has given good service under acid conditions, and the amount of equipment associated with the seal system has been considerably reduced. To assure at all times that flushing oil is admitted to the glands on these acid pumps a magnetic rotameter (Fig. 7) was installed on the flushing oil lines. This rotameter is totally enclosed and is of stainless steel construction so that damage due to the acid will be negligible. The installation of this rotameter replaced an elaborate manifold with pressure gages for flushing oil addition, and to date has proved very effective in maintaining flushing oil of a sufficient, but small quantity, to the acid pumps.

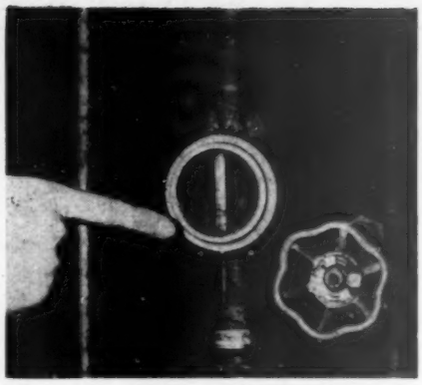

FIG. 7. Detail view of flushing oil rotameter. Note size of instrument compared with man's hand.

The instrumentation on the HF alkylation plant was considerably simplified as is shown on the process flow sheet (Fig. 5), and a number of unnecessary controls and control systems in the acid area removed. In addition, where possible, control valves have been changed from the acid stream to the utility stream. This expedient eliminates a control valve maintenance problem and a point of HF leakage.

On the El Dorado plant considerable attention was given to the problem of valves in HF service. On the revamped plant all valves under 2-in. in size, both gate and globe, are of solid monel construction. The valves larger than 2-in. are lubricated plug valves with a monel lined body and a stellited plug. These valves are packed with standard packing where this type packing is applicable. Again lead seal compound has been used in the assembly of the valves.

Summary of Operations

Since the startup of the revamped plant in May, 1951, there have been 32 shutdowns, most of them for periods of less than one day, to repair leaking tubes in the contactor tube bundles. This record gives the revamped El Dorado plant an operating factor of 93.0 per cent, comparing favorably with the operating factor of this unit of 85.8 per cent during the period 1944 through 1946. During October, 1951 the unit was shutdown for 21½ days to bring the refinery gasoline pool into vapor pressure balance. Even including this intentional shutdown the operating factor for the unit since revamping is 86.2 per cent.

The El Dorado alkylation unit is manned by a three-man crew consisting of a top operator, one assistant operator for the acid section of the plant, and a control board operator for the fractionation section. In addition to this operating force there is scheduled a valve turner who works eight hours a day seven days a week. The duties of the valve turner are to lubricate all plug valves and to see that all plug valves are in operable condition. Any valves that cannot be operated are tagged for repair during the next shutdown. There is an additional auxiliary day man carried at this unit with the title of equipment man, whose duties are to clean and maintain safety equipment for this unit.

Normally operations of the alkylation plant have been satisfactory and since the startup there has been one complete inspection of this unit. During this shutdown all facilities were entered and it was necessary to completely prepare the acid section for entering during the shutdown. The procedure followed during this shutdown was to blow down the acid vessels to the blowdown area and to then evacuate the vessels with the evacuation system provided for this operation. Following the evacuation the vacuum on this system was broken by the addition of ammonia gas followed by a flushing of the vessels with lime-water. No traces of acid were found in the unit during this shutdown, and engineering inspection indicated no points of excessive corrosion.

Safety Experience

The record of acid injuries on the alkylation plant at El Dorado has been very good with only 15 acid burns being recorded since the initial operation of this unit in 1944. Since the startup of the unit May 1, 1951, there has been only one acid burn and this excellent record is attributed to the men's respect of the hazard involved when working around HF acid. The acid area of the alkylation plant is surrounded by a low curb painted yellow, and the entire acid area is covered with lime-stone chat. Signs are posted at the area boundaries reading "Acid Area — See Foreman Before Entering". To enter this acid area all men, either operating or maintenance, are required to wear face shields, slicker suits, and Neoprene overshoes. The equipment man maintains this equipment in excellent shape, and daily cleans and sterilizes these items. After use all safety items are necessarily neutralized. The plant area contains four safety showers along with eye wash fountains. Lime-water baths are distributed throughout the area for the neutralization of tools and gloves. It is believed the excellent safety record on El Dorado's plant is a result of having the safety equipment available, strict enforcement of the safety rules, and probably the greatest factor, the realization by the men that they are working with an extremely dangerous chemical. * *

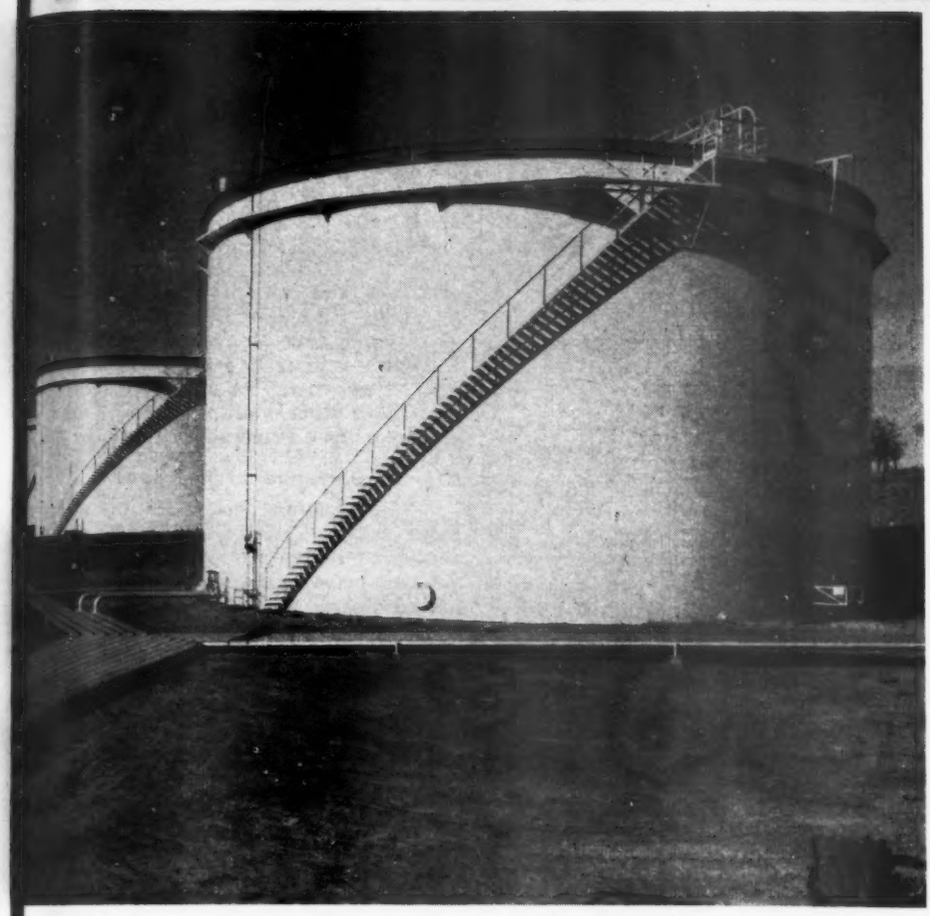

FIG. 1. Scene at Sun-Ray Oil Company in Drumright, Oklahoma. Floating roofs at top of their travel and still functioning with full efficiency.

Engineering Factors in Selecting Floating Roofs

JOHN H. WIGGINS

AMERICA'S petroleum industry is vitally concerned with the conservation of natural resources. This has manifested itself in many ways, one of the most important of which is the trend toward the use of floating roofs in oil storage tanks. Floating roofs now in operation in the United States result in a saving of many millions of dollars worth of gasoline that would otherwise be lost by evaporation from gas-tight cone-roof tanks. These savings that have been made through lessening of vapor losses result in maintenance of quality of gasoline through retention of volatile fractions.

When a conservation engineer faces the problem of recommending a particular type of floating roof best suited to the requirements of an existing installation, he should be able to recognize the important factors in selection. As with every manufactured product, a floating roof should be engineered to perform a specific job at a cost that can be justified on the grounds of dollars and cents savings. Over-engineering can be costly.

What Is a Floating Roof?

It would be well at this point to stop and review the history of how the floating roof came to be what it is, and how it stops evaporation losses. The modern floating roof with annular compartments, adequate drainage, and efficient seals has been the result of evolution and not revolution.

The earliest floating roofs were pan roofs that were extremely simple in design. The basic idea of changing from a fixed-roof tank to one with a roof which floated on top of the stored product was developed to reduce the fire hazard and cut evaporation losses. As the nation's economy became more and more dependent on the petroleum industry it became essential that losses of the higher fractions of volatile products be kept at a minimum.

When fitted with an adequate seal between the deck and tank the pan roof is capable of reducing evaporation losses, but suffers from the disadvantage of instability. The deck of a pan roof has very little slope and does not give satisfactory clean drainage. The pan roof is subject to tilting since the water load is never evenly distributed. This tilting effect can submerge the edge of the deck and cause the roof to sink.

As a means of adding stability to the pan roof, open compartments were built around the perimeter of the roof. But this step brought up the problem of draining these open compartments, when they were loaded with rain water.

Covered Pontoons Developed

The next phase of development of the floating roof saw the application of a watertight roof to the outer ring of open compartments. This cover was sloped down toward the center of the deck for drainage purposes and welded to the bulkheads to provide vaportight compartments. Though each compartment

EXCLUSIVE

THE AUTHOR

John H. Wiggins is associated with the General American Transportation Corporation, Chicago, Illinois, exclusive dealers of Wiggins conservation structures, manufactured by the John H. Wiggins Company. He is a graduate of Stanford University in civil engineering. After a year in the jungles of Brazil on reclamation work for the Brazilian Government he was associated with the Bureau of Mines at Washington, D. C. and Bartlesville, Oklahoma with a year out for World War I as a Second Lieutenant in the Air Corps.

He was personally acquainted with many of the pioneer leaders of the petroleum industry. A story is told about two of them, W. F. Gates, president of the Prairie Oil and Gas Company and R. A. Miller, vice president of Indiana Pipe Line Company. They were inspecting a 55,000-bbl tank filled with crude oil and equipped with a Wiggins floating roof. Miller, who was acquainted with the structure, waited until they were on the roof and then lit a cigar. Gates was so astounded he almost fell off the tank. Although this was not good practice, nothing happened except that it made quite an impression on Gates. He later became a firm advocate of floating roofs.

This incident followed the well known story of Wiggins in 1923, walking around a floating roof with the tank filled with gasoline with a lighted blow torch. With oil running out of their ears few oil men felt need for conservation.

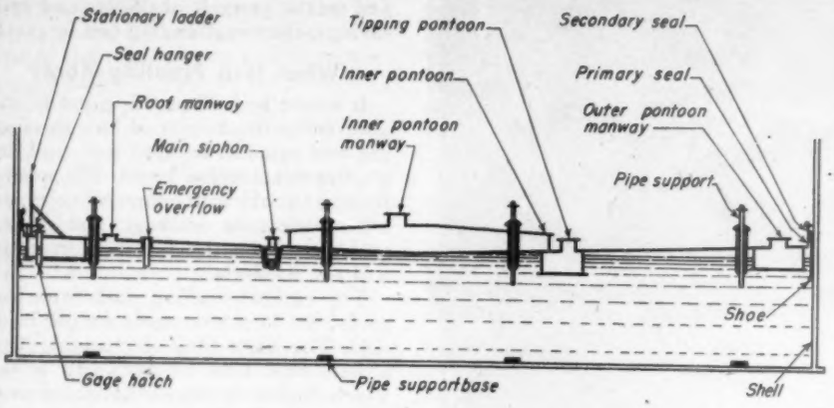

FIG. 2. Cross section of floating roof more than 60 ft in diameter.

was isolated from the others, inspection was difficult because of the low headroom, presence of internal trussing, and width of the compartments. The extra weight of this ring of compartments made it necessary to depress this area below the central single deck portion in order to carry the load.

Drainage was still not completely satisfactory after the annular compartments had been developed. Engineers expressed the desire for a floating roof that would drain the entire surface exposed to rainfall substantially dry. Maintenance of floating decks made it important to design the covered compartments for easier inspection during erection and service.

Solving a Triple Problem

A three-fold problem: Satisfactory drainage, easy inspection, and load carrying ability with economical use of steel, was solved by the design of a deck with an annular covered pontoon, a center covered pontoon, and an open deck between the pontoons. The reasoning behind this design follows.

In order to obtain proper drainage, either the pitch must be quite steep or any fabrication buckles must be removed from the deck plates to allow a lower pitch. A floating roof is limited in the steepness of its pitch by the height that the outer rim of the deck can be made. Beyond an optimum limit the higher this rim, the more expensive the deck and the more cumbersome and expensive will be the sealing shoes. This is a disadvantage because the seal is the most costly part of a floating roof.

To gain proper steepness for drainage the weather surface should slope down from the outer rim and also down from the center to a collection trough located between the center of the roof and the perimeter. With this type of construction it is possible to build the proper slope into the covered pontoons—¾ to 1½ in. per foot. (This design of roof is applied to tanks greater than 60 ft in diameter.)

The single deck section of the roof has several features that promote rapid, complete drainage. It is built to a certain pitch and when floating the center pontoon is dropped a few inches and the single deck is slightly stressed either by its own weight or the buoyant effect of the liquid on which it floats. The smaller the single deck dimension the easier it is to drain. The single deck radial dimension is smaller if it lies between a center pontoon and an annular pontoon as contrasted with a floating roof having an annular pontoon only (it is this radial dimension that must be drained). Finally, the use of radial plates allowing radial welds and eliminating cross welds in critical areas causes this open space to drain nearly perfectly.

Present-day practice in petroleum storage seldom allows the draining of water through the stored product. As a result it is usually necessary to install a pipe or hose drain to lead the water out of the tank. The drain should be designed for proper functioning with a minimum of maintenance. It should not kink or float and it is desirable that it allow replacement without the necessity of cleaning out the tank.

Compartment Accessibility

Building a floating deck with outer and center pontoons makes it possible to build the annular pontoon with a comparatively small radial dimension. This eliminates the necessity for obstructive truss members inside the compartment and allows ample space for moving around to inspect the condition of the roof. The inner and outer rims can be high enough for ample headroom. For example, in a 120-ft diameter tank the outer rim may be 36 in. high and the inner rim 29 in. high with an 8-ft radial dimension.

As this annular covered compartmented area has a small radial dimension it is economical to install a large number of bulkheads. This improves the inspection characteristics of the roof, because each compartment on a 120-ft diameter roof has a radial dimension of 8 ft and a circumferential dimension of 29 ft. As a result, every point inside a compartment is less than 14 ft from a centrally located manhole. One type of center pontoon has no trussing and is almost as easy to inspect as the open deck, as it is several feet high at the center. Another type has radial trusses and an inspection manhole for each truss compartment with ample headroom.

Less steel is required to carry a given load when the roof has a central pontoon and an annular pontoon with a single deck between them. As a heavy snow load will distribute itself fairly well over the entire roof surface it is the water load that must be handled. The small radial dimension of the open deck will sag less than the greater dimension of a central open deck and more speedily build a water depth that can be taken care of by an emergency overflow.

Importance of the Seal

As the floating deck rides up and down on the surface of the stored product, losses, if any, are to be expected at the area between the floating deck and the tank shell. That is where the seal enters the picture as the most important functional part of a floating roof.

A primary seal was developed for the first pan roofs with riveted shells and consisted of short, stiff metal shoes mechanically held against the tank shell and a vaporproof curtain designed to retain the vapors within the sealing space.

An effective modern design of primary seal uses long, circumferentially limber shoes, which are pushed against the tank shell at close intervals.

The shoes are made of light gage metal as a continuous cylindrical ring and maintain a sliding contact with the tank shell. Spring-actuated pushers exert a uniform outward pressure on the shoes midway between top and bottom, and effectively keep the roof centered in the tank. Flexibility of the long shoes makes it possible to have an effective seal at all points around the perimeter of the floating deck.

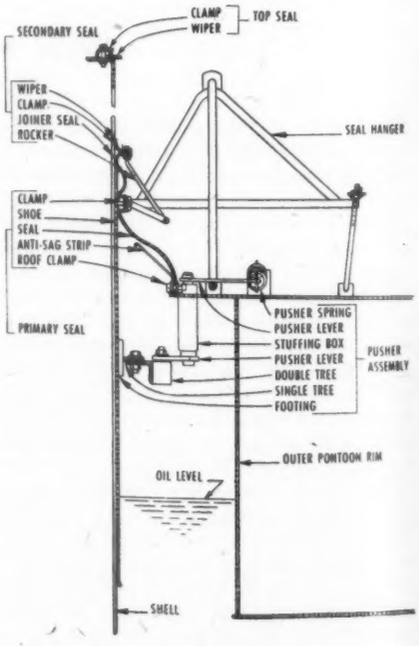

FIG. 3. Cross section of Wiggins triple seal for floating roof.

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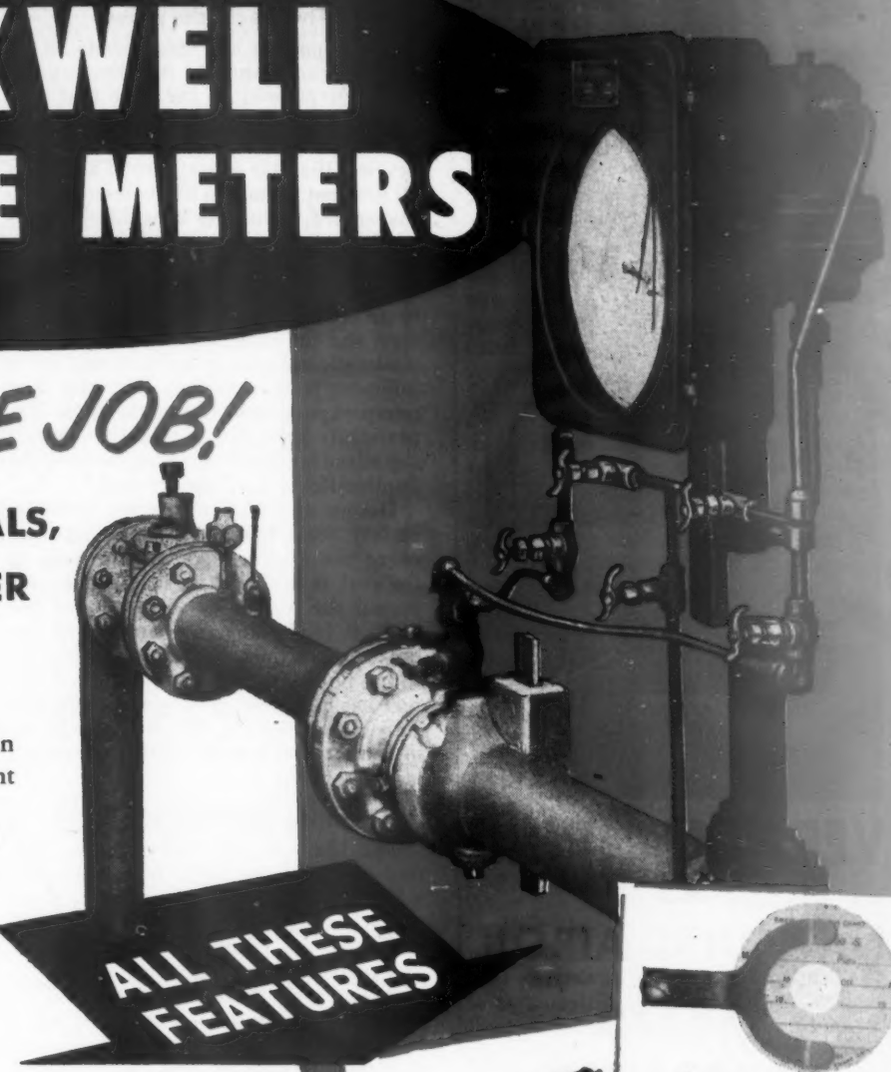

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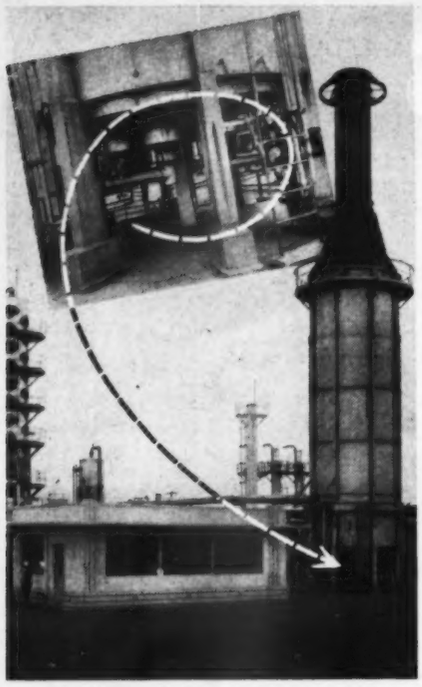

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The Secondary Seal

Developments and refinements of the primary seal improved its efficiency but research pointed to the fact that economic improvements could be made. This resulted in the design of a secondary seal that has accomplished at least a 50 per cent reduction in the losses which take place when only a primary seal is applied.

The condition that demands a secondary seal is pulsation due to wind. As there is always a space between the seal shoe and the tank shell, a wind of even moderate velocity is able to set up a pumping action in this thin slot and pump vapors right out of the tank. Experiments have shown that this pulsating effect is effectively minimized by the application of a secondary seal.

Design of both the primary and secondary seals has had to take into account the usable height of the tank. If the seal is designed so that it does not permit the roof to go to the top of the tank, it is limiting the capacity of the tank and partially defeating the conservation purpose of the floating roof. A top seal has also been developed for the top rim of the tank so that a seal will be maintained no matter what the position of the roof.

Painting the Floating Roof

The life and efficiency of a floating roof are increased if the deck is painted a light color and the paint kept in good condition. As is the case with any metal structure, the paint prevents corrosion and reduces maintenance expense.

Experiments have shown that white paint is most effective at reducing solar heat transfer. Actually, in the operation of a modern floating roof the heat that reaches the stored product through the roof is of much less consequence than the heat that is transferred through the walls of the tank. The sun heats the tank shell through most of the day, thus raising the temperature of the product between the shoe and shell where most of the evaporation loss occurs. The product, which is heated beneath the roof, is retained within the outer rim during the day. It is cooled at night without ever having reached the sealing space.

If any boiling loss is to occur it will most likely take place at the side of the tank. In the gas-tight vapor space beneath the seal boiling can occur at a point where the liquid is hottest. At exactly the same time condensation can occur where the liquid is cooler.

A Set of Specifications

So far this discussion has been devoted to showing the evolution of the modern floating roof and why it is built the way it is. But the engineer that has decided that floating roofs are the answer to his conservation problem should have a check list to use as a guide to the purchase of this equipment.

1. Roof shall not sink due to any reasonable cause such as:
   a. Roof drain not operating.
   b. Opening in the deck.
   c. Snow load of 25 lb per sq ft evenly or unevenly distributed.
2. Roof should not fail when resting on roof supports because of:
   a. Snow load (as above).
   b. Water load.
   c. Settling of foundation.
3. Roof should have best possible drainage to prevent:
   a. Corrosion and paint deterioration.
   b. Water load from causing error in gaging apparatus.
4. Enclosures or pontoons should be roomy and accessible to allow easy inspection and maintenance.
5. Roofs that are to be used on tanks storing corrosive liquids should be designed so that the under surface of the roof is always in contact with the product.

Seal Characteristics

1. Seal should contact the shell of the tank as closely as possible to reduce vapor loss caused by pulsation due to wind currents.
2. The seal should function at all levels of liquid in the tank.
3. Materials used in the mechanism of the seal should be corrosion-resistant to contribute to long life.
4. Elements of the seal mechanism should be adequate to perform their required functions but not so expensive that the cost of the seal will be excessive.
5. For most volatile liquids a secondary seal should be used.
6. It is desirable that the seal supporting and actuating mechanism be where it can easily be checked and serviced.

Performance Assured

If a floating roof meets the requirements set up by this check list the engineer can be assured of proper performance with minimum maintenance expense. Virtually any floating roof will do the basic job for which this type of equipment was developed, but costs of maintaining the roofs will differ. Other factors being equal, it is the roof that offers the lowest yearly cost that will satisfy the demands of most conservation engineers.

(Editor's Note: This is the first of a series of articles devoted to conservation equipment. The next article will analyze the history of the design and development of seals applied to floating roofs.)

Richfield to Expand Plant

A $40,000,000 refinery expansion project to meet increased military aviation fuel requirements and the West's growing demand for gasoline has been announced by Richfield Oil Corporation. As part of this expansion at Richfield's Watson Refinery near Long Beach, California, Petro-Chem Development Company has been awarded the furnace contract for two 30,000 bbl-per-day vacuum heaters. The project includes a new fluid catalytic cracking unit which will boost total gasoline output by more than 40 per cent to 2,750,000 gal daily.

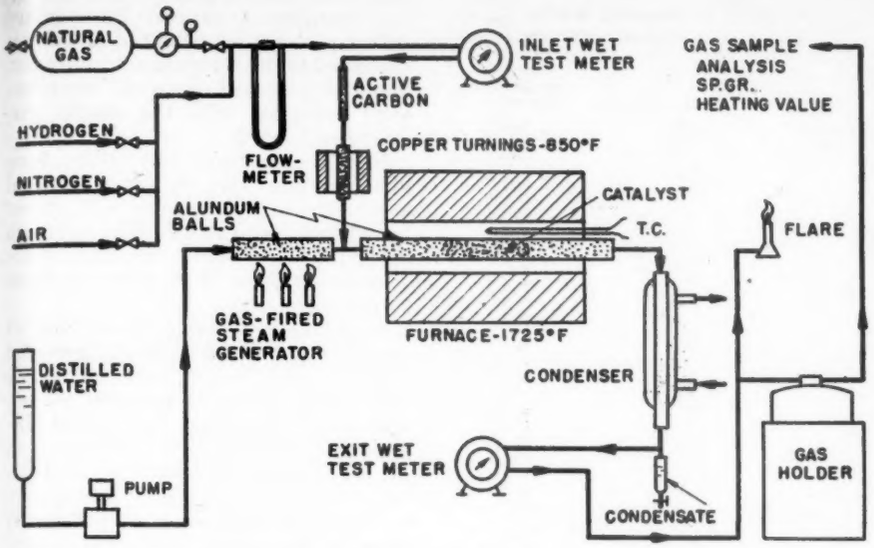

FIG. 1. Laboratory apparatus used in screening tests.

Improvement of Catalysts and Catalyst Supports†

Increased efficiency of catalysts achieved in research show need for improved process design to utilize advantages

C. H. RIESZ,‡ H. A. DIRKSEN,* W. J. PLETICKA*

Catalytic cracking, initially developed for peak-load gas production, has more recently become an important base-load gas production operation in the catalytic conversion of natural gas. Factors which may provide decreased investment costs thus become vital. Improved catalyst effectiveness is one element in increasing plant capacity. A laboratory and pilot-plant study of supports for nickel cracking catalysts revealed periclase (fused magnesium oxide) to be particularly effective; certain alumina preparations and selected refractory compositions were also found useful. Addition of small amounts of magnesium oxide or aluminum oxide promoter to the nickel, by co-impregnation, enhanced the activity of stable but relatively low-activity catalyst preparations. Possible decreases in nickel concentrations were indicated as a means of conserving nickel in case of limitations in nickel supply.

THE advent of natural gas to new areas has had the impact of accelerating the acceptance by the gas industry of catalytic cracking as a gas production method. No small part of this rapid acceptance can be attributed to the fundamental research which preceded plant application, one dividend of the research phase of the PAR plan established by the American Gas Association. The feasibility of catalytic cracking was established under this program in 1945.[1] Use of nickel as the preferred catalyst was demonstrated by an intensive study covering a wide variety of possible catalytic agents and compositions.[2] Later, the poisoning of nickel catalysts by sulfur was evaluated and shown to be of small consequence, for present commercial conditions, providing certain regeneration procedures were followed.[3] Laboratory and pilot plant studies indicated that nickel dispersed on refractory alumina spheres was a particularly useful form, an observation since confirmed in gas industry application.[4]

The objective of the present investigation was to decrease the investment costs per 1000 cu ft of plant capacity by means of improved catalyst activity. To this end, the effects of three principal variables of the nickel catalyst composition were studied:

1. Support
2. Promoter
3. Nickel concentration

As the conversion of natural gas has recently assumed wide-spread interest, the natural gas-steam reaction was used as the basis of the study:

$$CH_4 + H_2O = CO + 3H_2$$

$$CH_4 + 2H_2O = CO_2 + 4H_2$$

In the present application of catalytic cracking, a major factor limiting capacity is the transfer of heat required by the conversion. Normal input rates for natural gas are equivalent to a space velocity of 500 std cu ft per cubic feet catalyst-hour or less. At these conditions and with temperatures in the range of 1500-1700 F, the conversion of natural gas is essentially complete, regardless of the intrinsic activity of the catalyst. Investment costs can be decreased materially, however, by use of space velocities much higher than those now employed, with subsequent increases in plant capacity for a given size of catalytic reactor.

Preliminary tests indicated that such a sharp differentiation of catalysts became possible if the space velocity was increased to 3000 std cu ft of natural gas per cubic foot catalyst-hour in the laboratory apparatus.

Experimental Work

Laboratory Apparatus for Screening Tests. Natural gas was compressed to 400 psig and transported to the laboratory in stainless steel tanks (Fig. 1). After passing through a flow meter and wet-test meter the natural gas was passed first over active carbon, and then over copper turnings heated to 850 F, to remove impurities that might influence the results. Steam was prepared by pumping distilled water through a gas-fired generator. The natural gas-steam mixture was next passed over alundum spheres to preheat the mixture, and then over 1.32 oz (39 cc.) of catalyst (8-14 mesh) maintained in a 4-in. section of a ⅞-in. ID quartz tube. The temperature of the furnace was maintained at 1725 F as measured by means of a chromel-alumel thermocouple located at the center of the quartz tube. Undecomposed steam was condensed and the condensate collected. The cracked gases, after metering by a wet-test meter and sampling in a water-sealed gas holder, were flared.

Natural Gas. The natural gas used was obtained at the Crawford station of the Peoples Gas Light and Coke Company. An average of representative mass spectrometer analyses is given in Table 1.

Supports. Supports and catalysts were obtained from various manufacturers listed below:

Aluminum Company of America: T-71

TABLE 1. Analysis of Chicago natural gas. (1951 average)

Methane, CH_4	80.0
Ethane, C_2H_6	6.0
Propane, C_3H_8	3.0
Butane, C_4H_{10}	1.0
Nitrogen, N_2	10.0
Total	100.0

†Presented at Production and Chemical Conference, New York, May 26-28, 1952.

‡Armour Research Foundation of Illinois Institute of Technology, Chicago, Illinois.

*Institute of Gas Technology, Chicago, Illinois.

alumina, T-74 alumina, sodium aluminum carbonate.

Attapulgas Clay Company: SB-1909 11.3 per cent nickel on Porocel (0.4 per cent MgO).

Carborundum Company: AMM alumina, AMF alumina, SAEHF alumina, CMF silicon carbide, CMM silicon carbide, CEHF silicon carbide, CEHF silica.

Davison Company: No. 797 cracking catalyst, No. 814 cracking catalyst, Grade 02 silica gel.

Enjay, Inc.: BR-206 Reforming catalyst, BR-245 Reforming catalyst, BR-410 Reforming catalyst.

Harshaw Chemical Company: Ni-x-L382-1T 3/16 in. 5 per cent nickel on active alumina, Ni-x-L382-2T 3/16 in. 10 per cent nickel on active alumina, Ni-x-L382-3T 3/16 in. 20 per cent nickel on active alumina, LM-354 Periclase, Ni-x-L533-12S 5.3 per cent nickel on periclase.

Johns-Manville: No. 408 Celite, No. 410 Celite.

Norton Company: LK-326 Silica-alumina, LC-202 Silicon carbide, LA-201 Alumina, TA-1221 Alumina, LM-354 Periclase.

Richard Remmey Son Company: 90-B6 Alumina.

Titanium Alloy Manufacturing Company: ZRI-558 Zircon.

United Clay Mines Corporation: Manchester Clay, New Jersey mine; Putnam Clay, Florida mine.

Westvaco Chemical Division, Food Machinery and Chemical Corporation: P-97 Periclase, S-96 Periclase, S-93 Periclase, S-90 Periclase, SFN-199 Periclase, SFN-200 Periclase, SFN-201 Periclase, SFN-859 Periclase.

Catalyst Preparation. All catalysts were prepared by impregnation. The calculated amount of nickel nitrate was dissolved in a small amount of water and heated. The dried support was immersed and allowed to soak up nearly all the solution. Heating was continued until all of the nitrate was absorbed. The impregnated catalyst was placed in a Vycor tube and heated to about 1200 F, and air was passed through it to drive off nitrogen oxides. After cooling, the catalyst was ready for use. In the cases where promoters were used, the calculated amount of promoter nitrate was also dissolved with the nickel nitrate. In all other respects, the procedure of preparation was exactly the same.

Method of Correlating Results. All of the screening tests were made under the conditions stated above. The value of a particular catalyst composition was rated by its degree of conversion; a catalyst that had a high conversion in the test was rated as relatively more effective than one with a low value. Small differences were not significant.

The method of computing the conversion previously used by Sebastian and Riesz in rating catalysts was employed.[2]

$$\text{Per cent equilibrium conversion} = \frac{\text{actual expansion}}{\text{equilibrium expansion}}$$

where expansion was defined as the increase in gaseous volume per volume of natural gas, or

TABLE 2. Support study. 5 per cent nickel catalysts

Support	Designation	Per cent equilibrium conversion
Periclase (MgO)	LM-354	100
	S-93	99
	S-96	97
	P-97	95
	S-90	95
	L-533*	95
	SFN-199	93
	SFN-200	91
	SFN-201	91
	SFN-859	91
Alumina (Al_2O_3)	T-74	94
	SAEHF	92
	LA-201	91
	AMF	86
	T-71	83
	90-B6	82
	AMM	62
	TA-1221	49
	IT	40
Silica (SiO_2)	SEHF	87
	408	67
	410	65
	02	30
Silica-Alumina (SiO_2–Al_2O_3)	Putnam	91
	Manchester	88
	797	69
	LK-326	64
	814	54
Silicon Carbide (SiC)	LC-202	84
	CMF	71
	CMM	50
	CEHF	36
Zirconium Silicate (ZrO_2–SiO_2)	ZRI-557	66

* 5.3 per cent nickel.

TABLE 3. Promoter study. 5 per cent nickel — 1 per cent promoter — 94 per cent alumina (TA-1221)

Promoter	Formula	Per cent equilibrium conversion
Magnesium oxide	MgO	97
Aluminum oxide	Al_2O_3	94
Chromium oxide	Cr_2O_3	83
Thorium oxide	ThO_2	82
Calcium oxide	CaO	76
Cerium oxide	Ce_2O_3	71
Boron oxide	B_2O_3	67
Manganese dioxide	MnO_2	65
Zinc oxide	ZnO	65
Copper	Cu	63
Vanadium oxide	V_2O_3	62
Barium oxide	BaO	61
Zirconium oxide	ZrO_2	58
Iron oxide	Fe_2O_3	54
Titanium dioxide	TiO_2	54
Silicon oxide	SiO_2	50
Tin	Sn	40
Blank		49
No nickel		28

TABLE 4. Promoter concentration study. 5 per cent nickel on alumina (TA-1221)

	Per cent equilibrium conversion			
Promoter wt. per cent	0.5	1.0	1.5	2.0
MgO	94	97	99	93
Al_2O_3	87	94	102	92
Cr_2O_3	66	83	78	....
ThO_2	70	82	78	....
CaO	73	76	77	71
Ce_2O_3	65	71	82	63
Cu	59	63	50	....

$$\text{Expansion} = \frac{\Delta v}{\text{volume natural gas entered}}$$

This procedure, in addition to its inherent exactness, also compensated for the small changes in steam-to-natural gas ratio and temperature which occurred in conducting the tests, and thus compared all test results consistently.

Discussion of Results

Support Study. Previous research at the Institute of Gas Technology had resulted in the use of 5 per cent by weight of nickel dispersed on stable refractory supports as the standard cracking catalyst. Therefore, to evaluate manufacturers' samples, a support impregnated with 5 per cent by weight of nickel was subjected to the standard screening test. Samples obtained from 12 suppliers were evaluated with the results presented in Table 2.

Periclase, a fused, crystalline form of magnesium oxide, showed exceptional and uniformly high conversion values for all samples (Table 2). The approach to equilibrium under the high space velocity condition of the test was above 90 per cent.

Alumina, as a stable, fused form of corundum or alpha alumina, provided supports for nickel catalysts which varied from 45 to 94 per cent conversion. It is significant that nickel dispersed on alumina spheres (Norton) in the preparation designated as TA-1221, and similar to the one used successfully in industrial application, is rated well down the list, giving 49 per cent conversion. This rating indicates that activity improvements in this well-established catalyst are possible, although the present plants are not designed for the conversion rates demonstrated here. The observation that sharply defined differences exist in the activity of various preparations shows that testing is necessary to establish relative performance.

Other supports including silica, silica-alumina, silicon carbide, and zirconium silicate were evaluated with the results shown in Table 2. In general, it might be said that periclase supports were rated uniformly high in conversion effectiveness, alumina preparations gave a range of values some of which were high, while other supports were found to have individual results requiring further evaluation.

Promoter Study. Whereas 5 per cent nickel catalyst prepared on alumina support TA-1221 was rated low in the support study (49 per cent), addition of 1 per cent by weight of selected promoter was found effective in providing high levels of performance for this catalyst. Table 3. Magnesium oxide and aluminum oxide promoters provided unusually high conversions. Rated by the screening test, magnesium oxide promoter gave 97 per cent conversion, and aluminum oxide promoter, 94 per cent. Other promoters rated slightly lower were chromium oxide, thorium oxide, calcium oxide and cerium oxide, in that order. Some 11 other promoters gave varying degrees of improvement, as shown in Table 3. One addition, tin, actually lowered the activity below that of the unpromoted nickel-alumina catalyst.

Thus, magnesium oxide and aluminum oxide are unusually effective in promoting the catalytic effect of nickel. This may be fundamentally related to the superior results observed when the fused, crystalline form of the same compounds are used as the support for nickel catalyst.

Promoter Concentration Study. As the promoter concentration study was based on the use of only one concentration, 1 per cent, there was a possibility that the relative ratings might be erroneous if other concentrations were used. To

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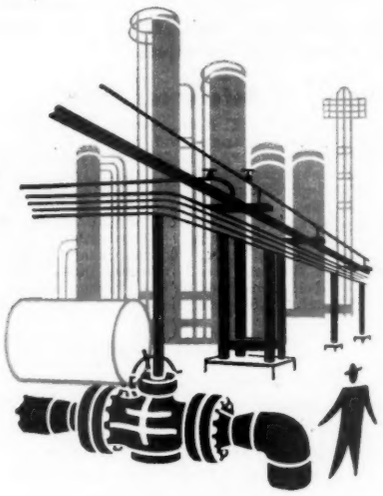

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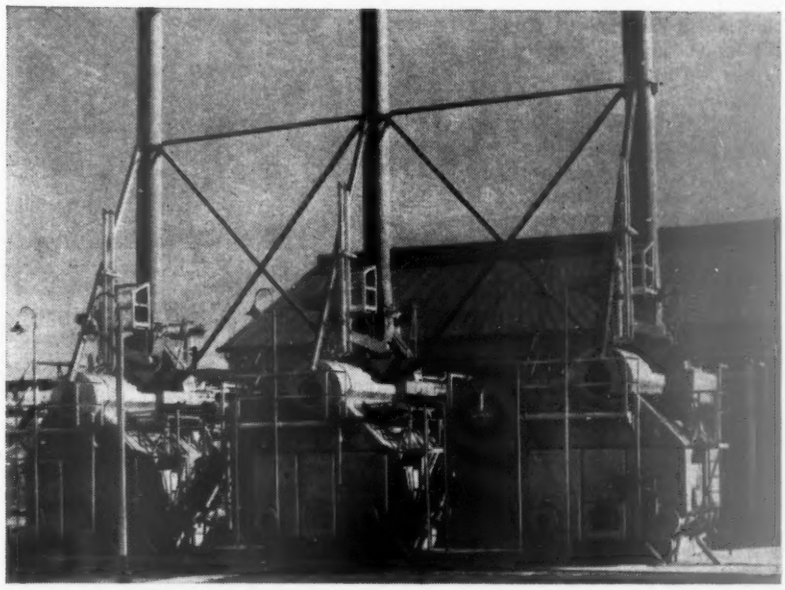

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check this, the best catalysts of the previous list, as well as copper, were tested at various concentrations within the range, 0.5—2.0 per cent by weight, with the same support, TA-1221, and with 5 per cent by weight of nickel catalyst. Table 4 shows that such concentration changes do not influence the relative order appreciably. Hence, the conclusion that magnesia and alumina have unusual promoting effects is again checked.

Results of a more detailed evaluation of magnesia and alumina promoter concentration are shown in Table 5. These data show that as little as 0.1 per cent of these promoters provide a marked improvement in conversion. A maximum at 1.0 to 1.5 per cent magnesia concentration and 1.5 per cent alumina concentration appear to be defined. It is believed that the variations observed between 0.1 and 0.5 in the case of alumina have significance, but will require more detailed study for elucidation.

Support-Promoter Study. The promoter concentration study described above and confined to the use of one type of alumina support was extended to other supports. As before, promoting effects were found with magnesia and alumina promoter concentrations of 0.5 to 1.5 per cent (Table 6). Both silicon carbide (LC-202) and silica alumina (LK-326) were improved to give 95-99 per cent conversion. The improvement in the case of the latter support was particularly useful, as the mechanical strength in sphere form appeared satisfactory but its activity was low without promoter.

Silica (Celite 410) was obtained as hard pellets of diatomaceous earth, a form which has many fine pores not stable at high temperature. The tests indicated that 1 per cent magnesium oxide promoter provided maximum improvement (83 per cent conversion).

Periclase (P-97) was found to behave slightly different than the other supports. Having a high activity, small additions of promoter actually lowered the conversion. Further additions, however, (to 1.5 per cent for magnesium oxide promoter, and to 1.0 per cent for aluminum oxide promoter) restored the initial activity.

Nickel Concentration-Porosity Study. The unusual activity of unpromoted periclase catalysts was further investigated by evaluation of four comparable periclase supports of widely different porosity. Data obtained upon impregnation with varying amounts of nickel are shown in Table 7.

Conversions with nickel impregnated upon 24 per cent porosity periclase increased with increasing concentrations of nickel, until a maximum was obtained at 4 per cent concentration. This performance indicates that nickel is spread uniformly over the surface of the support, and that increasing concentration increases the activity until bridging occurs, causing an effective loss of nickel available for reaction.

With the other, more porous periclase supports, there appear to be two such maxima. If the mechanism indicated above is valid, two kinds of pores or catalytic surfaces are formed at two levels of nickel concentration. There are then at least two such maxima caused by nickel bridging in these cases.

It is possible that the results reflect the characteristics of the single space velocity condition of the standard test. From a practical viewpoint, however, the data indicate that the relation of support porosity and nickel concentration is not a simple function of nickel concentration. The tests indicate the possibility that nickel concentrations may be lowered and still retain sufficient conversion effectiveness for economic application. This becomes especially significant if nickel allocations are restricted in the interests of national security.

TABLE 5. Promoter concentration study. 5 per cent nickel on alumina (TA-1221)

Promoter concentration weight, per cent	Per cent equilibrium conversion	
	MgO	Al_2O_3
0	49	49
0.1	75	85
0.2	80	91
0.3	92	88
0.5	94	87
1.0	97	94
1.5	99	102
2.0	93	92

TABLE 6. Support—promoter study. 5 per cent nickel catalysts

Support	Promoter conc. per cent	Per cent equilibrium conversion	
		MgO	Al_2O_3
Silicon Carbide, LC-202	0.0	84	84
	0.5	96	91
	1.0	99	88
	1.5	97	98
Silica-Alumina, LK-326	0.0	64	64
	0.5	80	92
	1.0	92	99
	1.5	95	92
Silica, 410	0.0	65	..
	0.5	1	..
	1.0	83	..
	1.5	70	..
			..
Periclase, P-97	0.0	95	95
	0.5	91	83
	1.0	84	95
	1.5	96	93

TABLE 7. Nickel concentration—porosity study. Periclase support

Nickel concentration per cent	Per cent equilibrium conversion			
	Porosity 24%	Porosity 29%	Porosity 37%	Porosity 52%
1	67	66	72	87
2	79	86	79	84
3	91	93	98	80
4	93	87	95	89
5	91	91	91	93
6	..	..	93	99
7	80	94	100	100
9	..	95	86	101
12	..	..	..	90

TABLE 8. Special catalysts.

Catalyst description	Per cent equilibrium conversion
5 per cent Ni on active alumina, 1T	40
10 per cent Ni on active alumina, 2T	75
20 per cent Ni on active alumina, 3T	86
11.3 per cent Ni, 0.4 per cent MgO on Porocel, SB-1909	96
Reforming catalyst, BR-410	66
Reforming catalyst, BR-245-206-410	50
Calcium-nickel-phosphate, U.S.P.-2,442,320	41
V_2O_5 on alumina, No. 910	25
Sodium aluminum carbonate	32
Calcium oxide (Baker)	33
NaF on alumina	6

Special Catalysts. Incidental to the main study, a number of special catalysts were tested with results as shown in Table 8. Active alumina required 20 per cent nickel by weight (3T) to obtain a conversion (86 per cent) somewhat comparable to a 5 per cent nickel catalyst prepared on fused alumina support. A bauxite impregnated with 11.3 per cent nickel and with 0.4 per cent magnesium oxide added (SB-1909) proved relatively effective (96 per cent); this catalyst has been proposed for commercial use. Two other reforming commercial catalysts, BR-410 and a triple-bed combination (BR-245, 206, 410), were rated low in the test (66 and 50 per cent). A calcium-nickel-phosphate composition patented for butadiene manufacture was rated low (41 per cent).

Vanadium oxide catalyst, useful in oxidation, was rated at only 25 per cent. Three alkali catalysts not containing nickel were found relatively ineffective; sodium aluminum carbonate, 32 per cent; calcium oxide, 33 per cent; and sodium fluoride on alumina, 6 per cent.

Pilot Plant Studies. The previous work was conducted with laboratory equipment, and it was necessary to evaluate the performance of selected catalysts in pilot-plant apparatus to provide an indication of their utility in full-scale equipment. Details of the latter work are included in I.G.T. Bulletin No. 20. In general, the pilot-plant tests are less discerning in differentiating the effects of support, promoters and nickel concentration. A considerable degree, however, of simulation of industrial conditions was achieved, important in evaluating the mechanical characteristics of individual catalysts. The insertion of "canisters" of selected catalysts in commercial operating units appears highly desirable as a final check before full-scale application.

The data from the pilot-plant tests confirmed the general nature of the laboratory conclusions, and emphasized the limitations in supplying in a continuous process the large quantities of heat necessary to effect high rates of conversion. Need for improved process designs to utilize the high potential gas-generating capacity of the improved catalysts is indicated.

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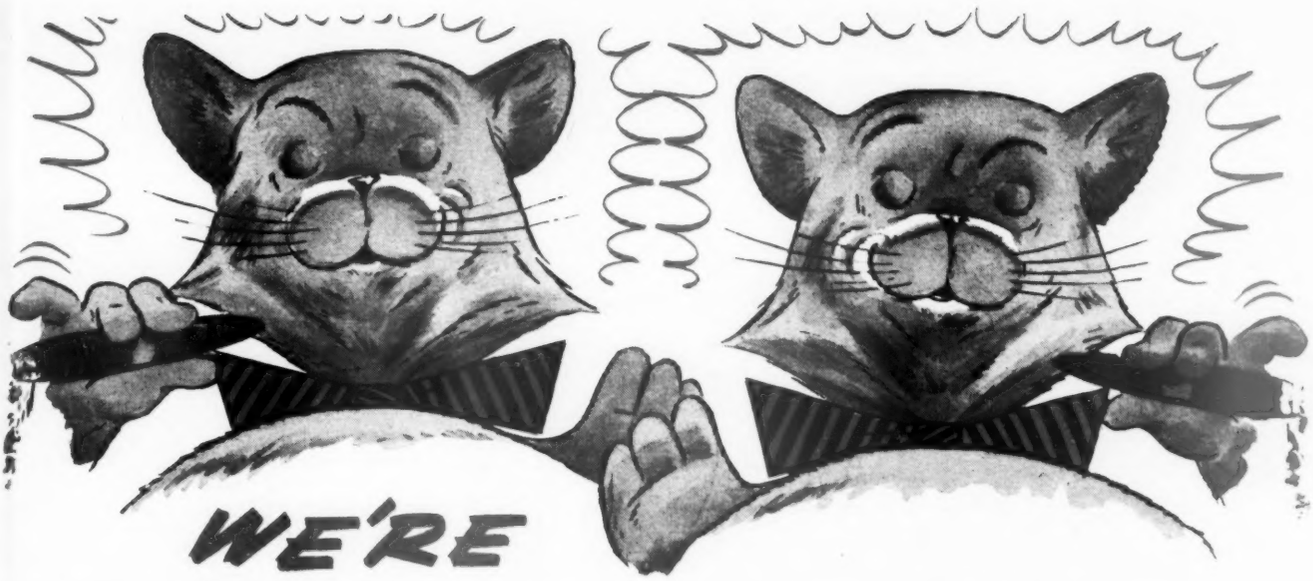

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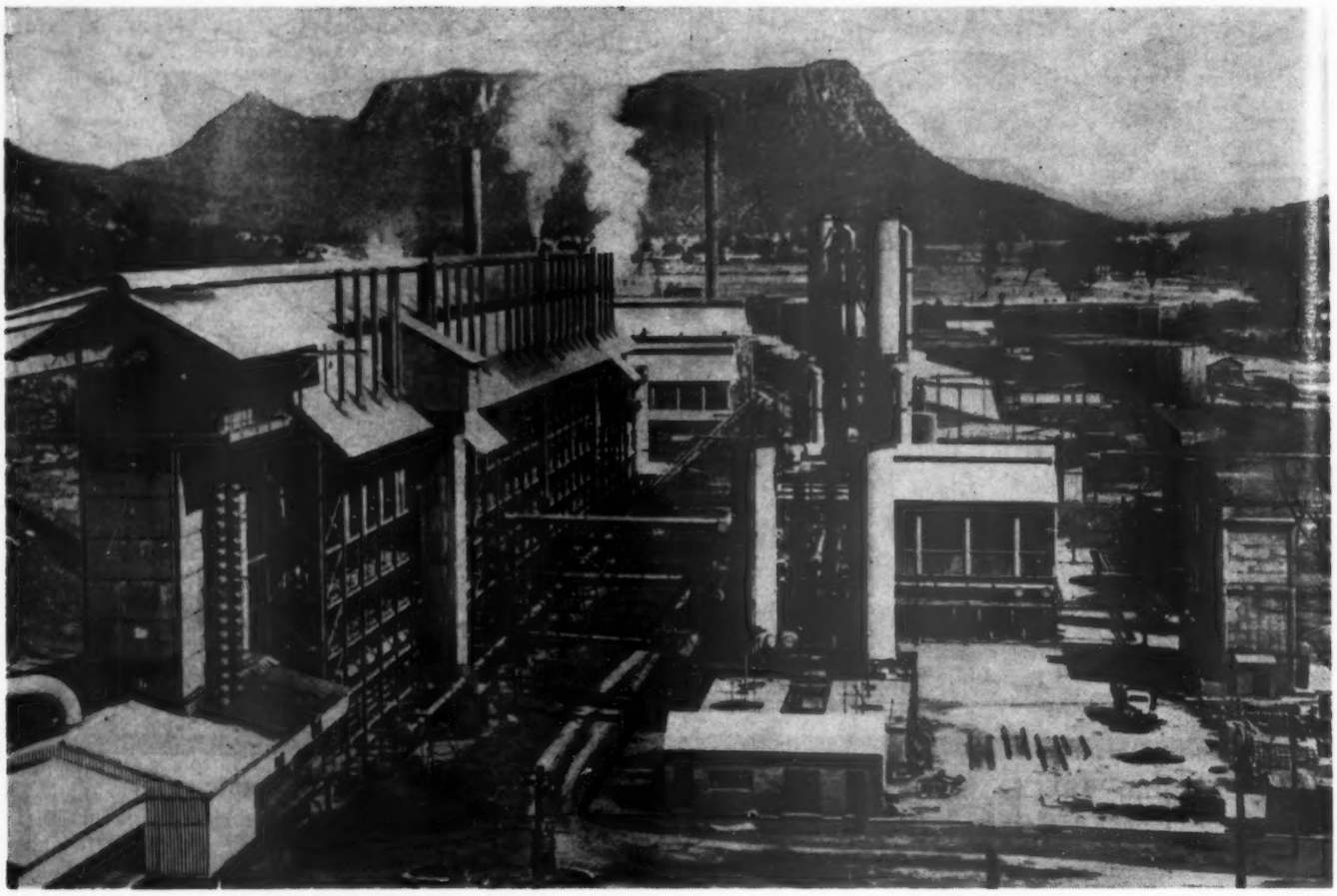


Fell retorts and retort naphtha absorbers at Glen-Davis, Australia.

Processing Australian Shale Oil

Cracking and reforming this raw material brings new possibilities to the growing petrochemical industry

DR. E. G. NOTTES*

The problem of producing standard gasolines, fuel oil, and petroleum coke from Australian crude shale oils and the manufacture of useful byproducts like cresylic acids, propane, and butane appears to have been solved in a technically sound and economic way.

Although generally shale oils yield less cracked gasoline than do most petroleum crude oils, this factor may be offset by adding thermally reformed retort naphtha recovered from the shale gases. Gasoline yields are still somewhat lower than those obtained from average petroleum stocks, however, mainly due to the chemical constitution of crude shale oil and its content of S, N, and O compounds (at the present time inherent in the retorting processes).

The byproduct possibilities of shale oils offer many interesting avenues for research and could make a valuable contribution to the economics of the industry. To compete with imported crude oils, however, a considerable reduction in mining costs in Australia is essential, unless a greater measure of protection is afforded in the form of tariff, embargo, or subsidy. Such protection is most unlikely.

*Imperial Chemical Industries of Australia and New Zealand Ltd., Melbourne. Formerly refinery superintendent, Glen Davis, N. S. W.

SEVERAL factors make some Australian oil shales highly suitable as a basic material for the synthesis of fuels, byproducts, and petro-chemicals. The amount of crude shale oil that can be recovered from torbanite by the usual retorting processes is sometimes above 100 imperial gal per ton[1] and the low sulfur, nitrogen, and oxygen content of some Australian shale oils does not greatly complicate the refining process.[a,2]

Crude shale oil contains an infinite variety of potential chemical compounds. Among these are aliphatic hy-

[a]Oil shale deposits that have been worked at Latrobe on the island of Tasmania seem to be an exception. Some authors[3] have described the oil shales there as "yielding an asphaltic and highly sulfurous oil on distillation, of rather poor quality."

Modern methods of processing, however, give promise of obtaining from this source, sulfur (or sulfur compounds) as a byproduct. The oil shale seam is also more uniform, extensive, and more accessible than some of the mainland deposits.

EXCLUSIVE

drocarbons, olefins and condensed nuclei-containing hydrocarbons. Also products of an aromatic nature, some with highly reactive carbon atoms in the molecule, moreover phenols, higher alkyl-phenols, tar bases, and substituted thiophenes, several of which could be used for the manufacture of raw materials for chemical industries.

The history of Australian shale oil exploitation[4] shows that since 1865 several attempts have been made to process oil shale and shale oils in this country but sooner or later competition from petroleum forced operations to stop. The reasons given today for the intended closure of Australia's only remaining synthetic fuels works (at Glen Davis, N. S. W.), which are dependent on oil shale, are reported to be economic ones.[5]

Due to the fact that Australia does not have producing oil wells now, however, there are sound arguments for continuing industrial development of the highgrade oil shale deposits on the Australian mainland.

The political unrest in the middle-east oil producing areas, the ever increasing demand for fuel oil by the rapidly increasing population, together with the pressing need for an independent source of oil for Australia's present needs and future petrochemical industries, make the development of her oil shale deposits a matter of importance.

It is certainly interesting to see that results of oil shale research published from time to time by the U. S. Bureau of Mines indicate the extent to which America is[6] preparing for the large scale exploitation of her oil-shale resources, and this in the face of the still vast oil fields on the American Continent.

The results of research on many aspects of Australian oil shales and shale oil production, from the scientific, analytical, and development points of view have been published in recent years.[b,7] There are several unpublished results from the large-scale processing and refining, however, which are worth mentioning to complete the basic information available for future use. If no petroleum is found in Australia, sooner or later circumstances might force renewed exploitation of her oil-shale fields.

Thermal Cracking and Reforming Operations

Descriptions of the selective two-coil Dubbs cracking plant (capacity 1500 bbl per day) with UOP catalytic polymerization unit, thermal reformer, and the usual acid treatment, rerun, and doctor treatment plant, at present in use treating Australian shale oil, have been given elsewhere.[7,8]

It has been pointed out that the cracking of Australian shale oils has certain peculiarities.[8] One of the last papers mentioned also that the reasons for several of these peculiarities have not yet been determined.[8] More research has been done, however, in regard to the determination of the chemical constitution of crude shale oil and shale naphthas, and to some extent an explanation for these peculiarities has been found.

[b] In 1947 technologists from the US Bureau of Mines visited Australia and came to Glen Davis, N.S.W. to study the shale-oil industries here. Later a report was issued which gives a very comprehensive description of the works and the state of the industry up to this time.: "Bureau of Mines, Report of Investigations 4790. Oil Shale Operations in New South Wales, Australia", by A. J. Kraemer and H. M. Thorne, July 1951.

TABLE 1.

	Average yield of 5 runs 1950 (Glen Davis crude oil).	Average yields from 25 deg API Mid-Continent crude (9)
375 F EP Gasoline	36.5 Per cent by weight	46.4 Per cent by weight
Polymer gasoline 10 RVP	4.0 Per cent by weight	4.0 Per cent by weight
Light recycle oil bleed off (while on coke operation)	2.3 Per cent by weight	——
Residuum oil (fuel oil) API gravity=1	24.4 Per cent by weight	18.0 Per cent (API grav.=7)
Coke	12.9 Per cent by weight	12.5 Per cent by weight
Gases	17.9 Per cent by weight	18.8 Per cent by weight

TABLE 2.

	%C	%H	%S	%N	%O
Paraffinic shale oil (Scottish)(11)	85.81	12.29	0.32	1.32	0.26
Asphaltic shale oil (Estonian)	82.45	9.62	0.86	1.07	6.00
Australian shale oil (Hartley 1905)(12)	86.93	11.93	0.37	0.58	0.11
Glen Davis crude (topped to 370 F	85.97	11.70	0.60	0.60	0.84*
Australian shale oil (Analyzed by U. S. Bureau of Mines, (6)	85.34	11.96	0.56	0.52	1.62†
Pennsylvania crude (13)	86.1	13.90	0.06	....	....
West Virginia s.g.=0.887 (14)	85.2	13.4	....	0.54	....
Mid-Continent (Oklahoma)(15)	85.0	12.9	0.76	....	....

* Unterzaucher method.
† By the difference method.

TABLE 3. Yields of cracking products from Glen Davis crude shale oil.

Run:	46	47	48	49	50	51	52
Yield of 370 F EP Gasoline by wt. %	36.2	36.96	38.03	37.3	34	37.38	37.2
Poly. yield by wt. %	4.13	3.4	3.8	3.5	3.95	3.02	3.67
Coke yields by wt. %	17.5	10.8	14.65	12.4	9.3	18.5	16.1
Average transfer Temp. Light oil coil during run	1011 F	1015 F	1015 F	1025 F	1021 F	1021 F	1020 F
Gasification by wt. %	18.6	17.5	18.2	18	17.0	21.9	20.4
Residuum in wt. %	21.2	25	24	22	30	18.7	21
Light oil side stream take off during coking operation, by wt. %	3	2	3.4	1.5	1.66	3.6	3.5

TABLE 4. Examples of 100 per cent cracking yields for the Dubbs process.[17]

Charge:	Texas (Amarillo) topped		Oklahoma fuel		Mid-Continent fuel	
API gravity	28.4		27.3		23.7	
Coke lb per barrel	50		59.1		61.3	
	vol %	wt %	vol %	wt %	vol %	wt %
Gasoline yields based on charging stock:	62.2	51.7	62.9	52.3	62.3	50.2
% furnace or diesel oil:	18.8		11.1		13.0	
% yield reduced to 370 F EP	48 wt %		48.4 wt %		46.5 wt %	

Yields of Gasoline

At present, Glen Davis is aiming to produce the maximum quantity of gasoline. Therefore no attempt is made to separate other products before cracking.

Table 1 compares the yields in cracking. The results show that Glen Davis topped crude shale oil yields a somewhat lower recovery than petroleum stocks with similar properties under the same operating conditions in the same type of Dubbs unit.

The main reason for the lower gasoline yields from shale oil appears to be the chemical composition of the oil. The elementary analyses of shale oils show a lower hydrogen content and very often a higher sulfur, nitrogen, and oxygen content that most of the comparable petroleum crude oils. The high operating temperatures in the retorts cause some dehydrogenation, aromatization, and cracking of the original kerogenous and bituminous substances that comprise the organic part of oil shale. This seems to a certain extent to be responsible for the occurrence of large amounts of olefins in crude shale oils. Secondary reactions of the oil vapors are also a factor. It is assumed that compounds with "Benzenoic structure" are present in the original kerogen.[10] These are the reasons for the lower hydrogen content of crude shale oil compared with petroleum oils of similar properties such as API gravity, boiling range, etc. Table 2, above, gives an illustration of the hydrogen, carbon, and sulfur contents of several comparable petroleum stocks with some crude shale oils.

It is known that the yield of gasoline that may be obtained from a stock is a function more of the hydrogen content of the stock than of any other characteristic.

Shale oil cracking stocks are generally poorer in hydrogen content than similar boiling petroleum stocks. This indicates that lower yields must be expected from cracking shale oils than from cracking petroleum stocks. Besides the somewhat higher content of S, N, and O in crude shale oils may also reduce the gasoline yields.

Nelson's Formula (16):

$$Y = 303 - 250S$$

Y = Yield of 400 F EP gasoline in vol per cent.

S = Spec gravity of charge (for topped crude oils)

would indicate a yield of 83 vol per cent of 400 F EP gasoline that equals 56.5 wt per cent of 370 F EP gasoline on coke recycle operation only.

(sg of shale gasoline = 0.735)

The yield on residuum operation only would be indicated by the equation[16]

$Y = 25 + 1.5\,(C - R)$.

Y = Yield of 400 F EP gasoline in vol per cent
C = API gravity of charging stock
R = API gravity of residue

(API gravity of Glen Davis Crude = 28.3, API gravity of Residuum 0) and it should be 67.4 vol per cent 400 F EP gasoline that equals 45.7 wt per cent of 370 F EP gasoline, from a given petroleum stock of characteristics similar to those of Glen Davis crude shale oil.

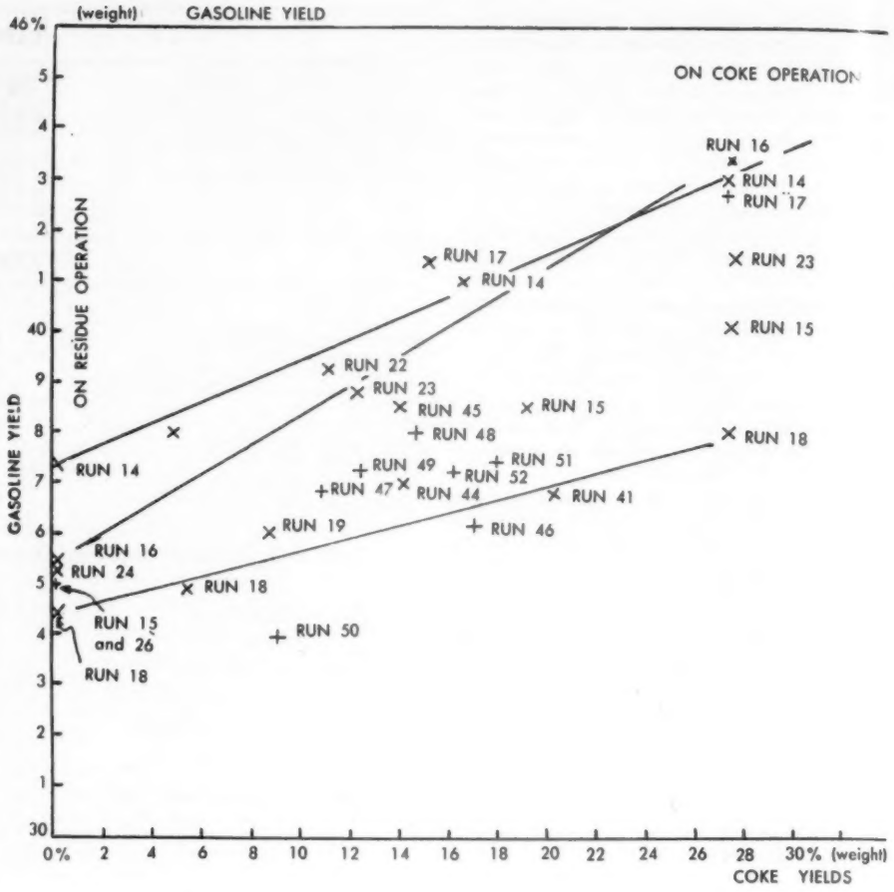
Table 4 shows some examples of cracking petroleum stocks giving higher gasoline yields than the shale oil in Table 3.

Some Operating Factors Influencing Gasoline Yields

Cracking Operations. Present specifications for gasoline[18] require the production of finished petrol with an average octane number of 70-72 (The octane number of the stabilized and refined pressure distillate is raised from 63 to the required level of 70 to 72 by the usual addition of TEL).

The operating conditions of the cracking units are adjusted to keep the octane number of the raw pressure distillate up to 63-64. Table 3 shows that similar to the cracking operation of petroleum stocks, the influence of increased temperature in the light-oil cracking section increases the gasoline yield. Compare run 46 with run 51 and 52 (taking into consideration that almost the same amount of coke is produced in all three runs). As in petroleum cracking, the gasoline yield from shale oil is higher on coke operation than on residuum and needs little comment.[c] It has been found that the best results are obtained when the transfer temperature in the heavy oil coil is maintained at 930 F. (Higher temperatures tend to increase the danger of coke deposits in the coil.) It also has been found that the transfer temperature in the light oil coil should not surpass 1030 F-1040 F. As can be seen from Graph 1 and Table 3, the gasoline yields on residue operation have been on an average of 6 runs 35.4 per cent by weight, and on coke operation 41.4 per cent by weight per 100 parts of crude. As most runs had to produce coke besides a certain amount of residue the gasoline yields of most of the runs are between these given limits.

Most runs (as for instance No. 22, 23, 45, 48, 49, 49 to 51 etc., see Graph 1) were done in such a way that, in the first week or so, only residuum oil was made. After some residuum was produced, it was switched to coke and only cracking to coke was done for a period of approximately two weeks. Finally, the rest of crude feed stock for the cracker was again used for cracking to residuum. Then the run was finished. The average time of a run seldom exceeds four weeks, as there was not enough crude feed stock for the cracker available, because of low output in the shale mine.



Graph 1. 370 F EP gasoline yields in per cent (weight) for several runs.

The gasoline yields for cracking only to residue can be found by extrapolation on the left side of Graph 1. The yields for cracking only on coke operation are then to be found at the right side of the graph.

As all gasoline was normally blended into one tank for finished petrol, the yield was an average of the two processes, i.e., "on coke" plus "on residuum" operation in most runs (except runs 24 and 26, which produced residue only).

Thermal Reforming Operation. As has been mentioned before, the yields of gasoline are increased by the addition of properly treated retort naphtha to the cracked gasoline. Crude retort naphtha is produced to the extent of a few per cent up to 12 per cent of the crude oil, in the retorting section of the shale works. The average of 1950/51 is 8.6 per cent (weight). Some of the properties of crude retort naphtha like specific gravity, boiling curve, octane number, sulfur content, and others have been given elsewhere.[3]

The composition of an average sample of retort naphtha with an octane number of 54 is given in Table 5.

TABLE 5.

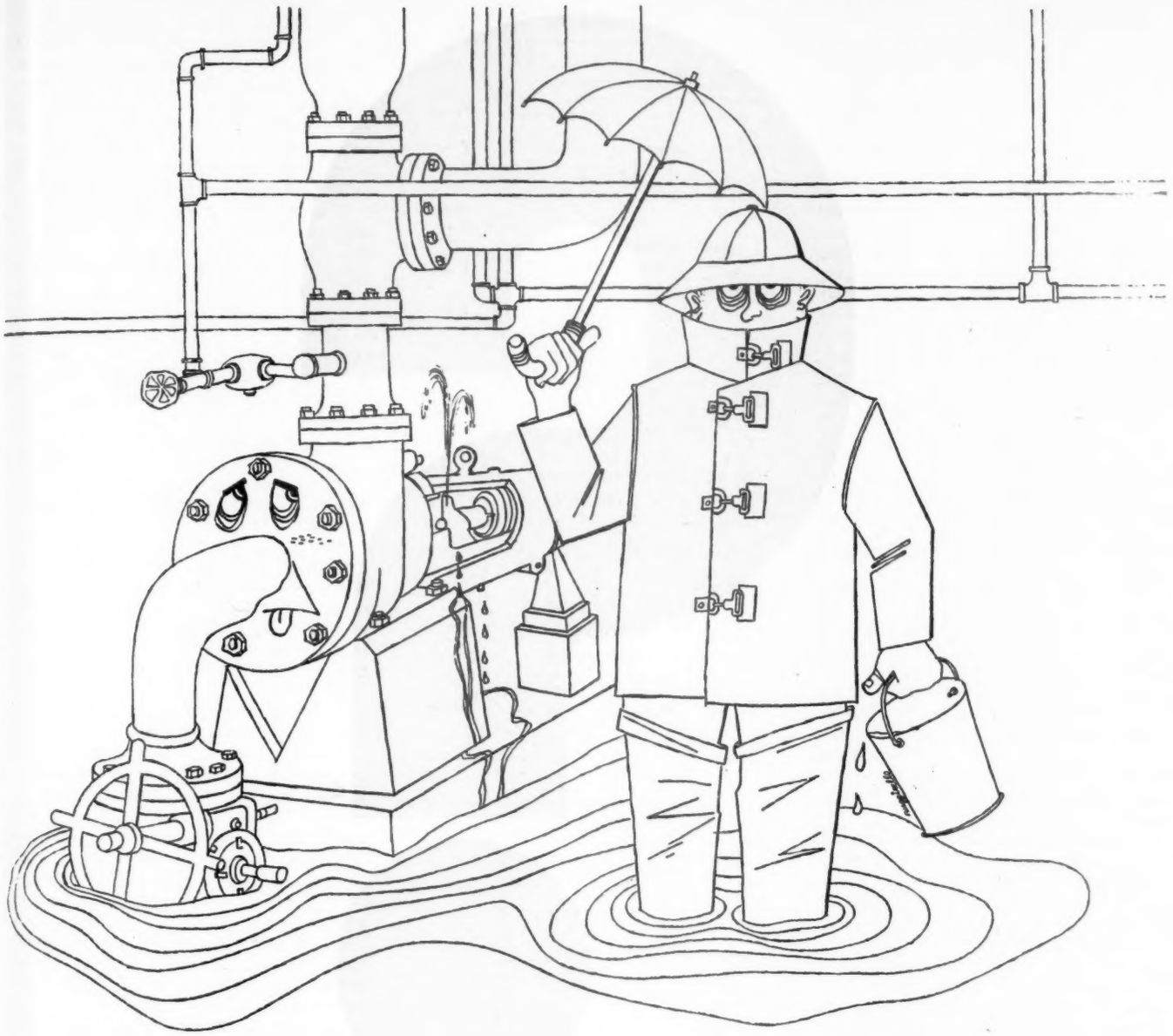
	Per cent
Olefins	30-34
Paraffinic hydrocarbons	47
Naphthenic hydrocarbons	13
Aromatics	7-10

Usually Glen Davis retort naphtha has an octane number between 53 to 57. In order to reform it to the required octane number of 62 to 63, it is necessary to keep the temperatures in the reformer heater section under strict control, and as constant as possible. It has been found in several runs that a transfer temperature of more than 1015 to 1020 F can, within several hours cause heavy coke deposits towards the outlet part of the coil. A somewhat lower temperature of 1000 F has not had much influence on the octane numbers and does not appreciably increase their range. This difficulty is increased in attempting to thermally reform "cracked shale naphtha." After a relatively short period of reforming there appears to occur a strong tendency for coke deposition in the hotter parts of the reformer coil. In case of the application of slightly milder temperature conditions no octane increase of the reformed, cracked naphtha takes place.

As can be expected, aromatic and olefinic content in the reformed gasolines have been increased somewhat. The reforming conditions for cracked naphtha on a typical run were found to be the following: See Table 6.

[c] Run 50 (Table 3) shows an average yield of 34 wt per cent of 370 F E.P. gasoline, there were also produced only 9.3 per cent coke but 30 per cent residue. Run 51 gave an average yield of 37.38 wt. per cent of 370 F EP gasoline and produced also 18.5 per cent coke besides only 18.7 per cent residue.

It can be seen from Graph 1 that the yields of 370 F EP gasoline, in runs 24 and 26 that did not produce coke and only residuum were in the order of only 35 wt. per cent. Run 15, which made 20 wt. per cent coke (besides a low amount of residue), gave an average yield of about 39 wt. per cent of 370 F EP gasoline (Polymer gasolines excluded).



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The average yield of reformed retort naphtha was around 80 per cent.

As has been reported elsewhere[6] the recycle ratio in the light oil section of the Dubbs cracking unit must be increased during the coke operation in order to maintain the required octane number of the stabilized pressure distillate. This is accompanied, however, by a build up of aromatics in the light recycle oil. It is interesting to note that as soon as the reformer is under real working conditions for reforming cracked shale naphtha, the charge pump of the cracking unit tends to slow down automatically.[4] At the same time the top temperature of the main fractionator column increases from 370 up to 420 F. To counteract this trend a certain amount of light recycle oil must be withdrawn constantly, in order to purge the unit from too much build-up of refractory compounds. Table 7 shows the build up of aromatics characterized by the increase of the specific gravity of the light recycle oil. The figures given represent an average of 6 runs during 1950.

Reforming of cracked naphtha necessitates the withdrawal of a certain amount of either cracked naphtha or light oil from the main fractionator column. In order to keep the top temperature of the fractionator even to 420 F, however, it has sometimes been found necessary to withdraw too much cracked naphtha. It has been, therefore, more advantageous to reform cracked naphtha only while "on residuum operation", instead of "while on coke."

An explanation of the aforementioned tendency of retort naphtha and moreover of the cracked naphtha to be susceptible to temperature increases in the reformer heater accompanied by coke deposition can be found in the observation that relatively fresh retort naphthas, which have not been exposed long to the influence of the oxygen of the air, do not show the tendency to deposit coke in the reformer to such an extent as longer stored products. It can be assumed that retort and cracked naphtha, owing to their unsaturation, form oxygen containing compounds like aldehydes, ketones, and peroxides upon standing in the storage tanks for a longer period of time. It is likely that these compounds tend, under the working conditions of the reformer coil, to induce deposition of coke. The existence of small amounts of diolefins and cyclic olefins in cracked shale naphtha and their well known high reactivity can explain to a certain extent the fact that old cracked naphthas tend still more to induce coke deposits in the reformer coil.

It is also known, however, that certain poly-substituted aromatic hydrocarbons (for instance mesitylene) are very reactive and tend to decompose at high temperatures. As retort and cracked shale naphthas contain besides olefins a certain amount of substituted, highly reactive, aromatic components their tendency for decomposition to coke in the reformer can be understood. As a result of one of the latest runs, however, it has been found that a change in the temperature, while increasing the throughput in the reformer, finally overcame some of the coke deposition in the reformer coil.

Increased throughput of fresh retort naphtha charge from 710 gal per hour to 810 gal per hour permits increasing the temperature of transfer up to 1050 F without coke deposition in the reformer coil. But the gain in octane numbers from 53 to 66 is at the expense of a lowered yield of about 60 per cent reformed gasoline, very strong gasification taking place at the same time.

Table 8 gives an indication of the average operating conditions.

TABLE 6.

Cross over temp. connection to heating	Cross over heating to soaking	Transfer temp.	Pressure	Charge
472 F	920 F	1010 F	475 psi	710 gal per hr

TABLE 7.

	s.g. of light recycle oil
On residuum operation with reformer on stream	s.g. = 0.902
On residuum only	s.g. = 0.908
On coke operation with reformer on stream	s.g. = 0.926
On coke operation	s.g. = 0.932

TABLE 8.

°F Cross-over con-vection to Rad.	°F Cross-over Rad. to soak.	°F Trans-fer temp	°F Quench	Pres-sure, psi	Charge gal per hr
534	938	1050	645	520	810

TABLE 9.

Temperature (°F)	% Solution loss	% Sulfur in finished gasoline
100	8.1	0.13
70	7.7	0.11
40	7.0	0.08
18	7.5	0.08

TABLE 10.

Temperature (°F)	% Loss	% Sulfur in finished gasoline
70	3.8	0.22
23	3.5	0.27

TABLE 11.

Specific gravity at 60 F	0.735
Distillation (IP 28/42 °F)	
ibp	97
5%	123
10%	138
20%	168
30%	190
40%	212
50%	236
60%	257
70%	276
80%	301
90%	330
95%	350
fbp	376
Over per cent	98
Reid vapor pressure (IP 69/45) lb	7.2
Gum: (ASTM D 381-46), mg/100 ml	1.8
Copper dish (UOP H 11.45), mg/100 ml	11
Doctor test (IP 30/44)	Sweet
Sulfur: Corrosive (IP 64/46)	Passes
Total (IP 62/42) % wt	0.18
Induction period (UOP H-6-40)mm	1000 plus
TEL ml/imp gal	1.70
Octane No. (Motor method)	70.5

Refining Shale Gasoline

The refining of shale gasolines is similar to the refining processes applied to cracked gasolines from petroleum stocks. It is interesting to note, however, that the sulfuric acid treatment of cracked shale gasolines has some peculiarities which could not have been foreseen when the application of the "cold acid treatment method" was tried out.

It is generally accepted that the treating temperature has a strong effect on the results of the treatment.[19] The desulfurization of many cracked petroleum stock gasolines is supposed to be favored by a decrease in temperature. The data of Morrell and Egloff illustrate the effect of temperature[20] on the sulfur removal of a California cracked distillate with 98 per cent sulfuric acid. See Table 9.

In comparison, cracked Glen Davis shale gasoline shows the interesting fact that a decrease of temperature does not decrease the sulfur content as should be expected.[21] See Table 10.

Therefore, to get the required sulfur content, it has been found more advantageous to effect the acid treatment at room temperature. An investigation of the properties of the re-run bottoms from the acid treated gasoline[22] showed that the sulfur compounds of cracked Glen Davis shale gasoline seem to be substituted thiophenes to a large extent.

In the acid treatment these thiophenes are further alkylated by olefins present and are only partly removed by the action of sulfuric acid. Usually higher temperatures favor the removal of aromatic hydrocarbons.[23] The bulk of sulfur compounds, however, is removed in the redistillation of the acid treated gasoline, remaining in the re-run bottoms. As re-run and doctor treatment operations are the same as in normal petroleum gasoline refining, they need no comment in this paper.[7]

An example of an analysis of typical finished shale gasoline is given in Table 11.

Some Properties of Crude Shale Oil

The high refractivity of the light recycle oil appears to have been caused by two factors. It is well known that, owing to long recycling operations, the longer a mixture of hydrocarbons is subjected to the influence of the cracking temperature the more cyclization and aromatization takes place even with originally non-aromatic stocks.[24] The other factor seems to be that the original content of substituted aromatics in crude shale oil is also responsible for the build up of refractivity in the light oil. The side chains of these molecules break off and lead finally to an enrichment of methylnaphthalenes and naphthalenes in the light recycle oil. Chromatographic methods and selective solvent extraction have been used to isolate approximately 20-24 per cent of substituted aromatics from crude Glen Davis oil. In some cases it was even possible to isolate varying, small amounts of naphthalene from samples of crude Australian shale oil.[25]

It is very difficult to interpret the

[6]After reforming, the quenched, cracked naphtha goes direct into the main fractionating column of the Dubbs cracker.[5]

somewhat different results that analytical methods, which are applicable to petroleum, give when applied to shale oils. For instance, the application of chromatographic separation and selective solvent treatment yield an aromatic fraction which comprises approximately 20-24 per cent of the original crude oil. Application of the aforementioned methods, sulfonation, nitration, and a critical evaluation of the conventional methods of oil analyses give results that should only be considered as rough values for further investigation. Table 12 gives the approximate composition and some other properties of a Glen Davis crude shale oil sample. The olefins are a very complicated mixture comprising a wide range of compounds, some of them being so reactive that diluted hydrochloric acid polymerizes them. For example, upon treating crude oil with a surplus of 87 per cent H_2SO_4 in a ratio of 3:1 it is possible to remove between 20 to 25 per cent by volume of the oil.

The raffinate then has the following properties: See Table 13.

The oil and acid insoluble sludge in an amount of approximately 10 per cent of the treated crude oil appears to consist mainly of polymerized olefins, pyrroles, and the sulfates of higher molecular weight tar bases, besides sulfonated hydrocarbons and contains 4.13 per cent nitrogen and 1.61 per cent sulfur.

Treatment of normal crude shale oil with hydrochloric acid immediately results in the precipitation of a water and oil insoluble dark sludge in an amount of approximately 3-5 per cent of the crude oil. After repeated washing with *n*-heptane or petrol ether, dilute HCl and water this sludge becomes semi-fluid and has the properties listed in Table 14.

TABLE 12.

S.G. = 0.880 — 0.900

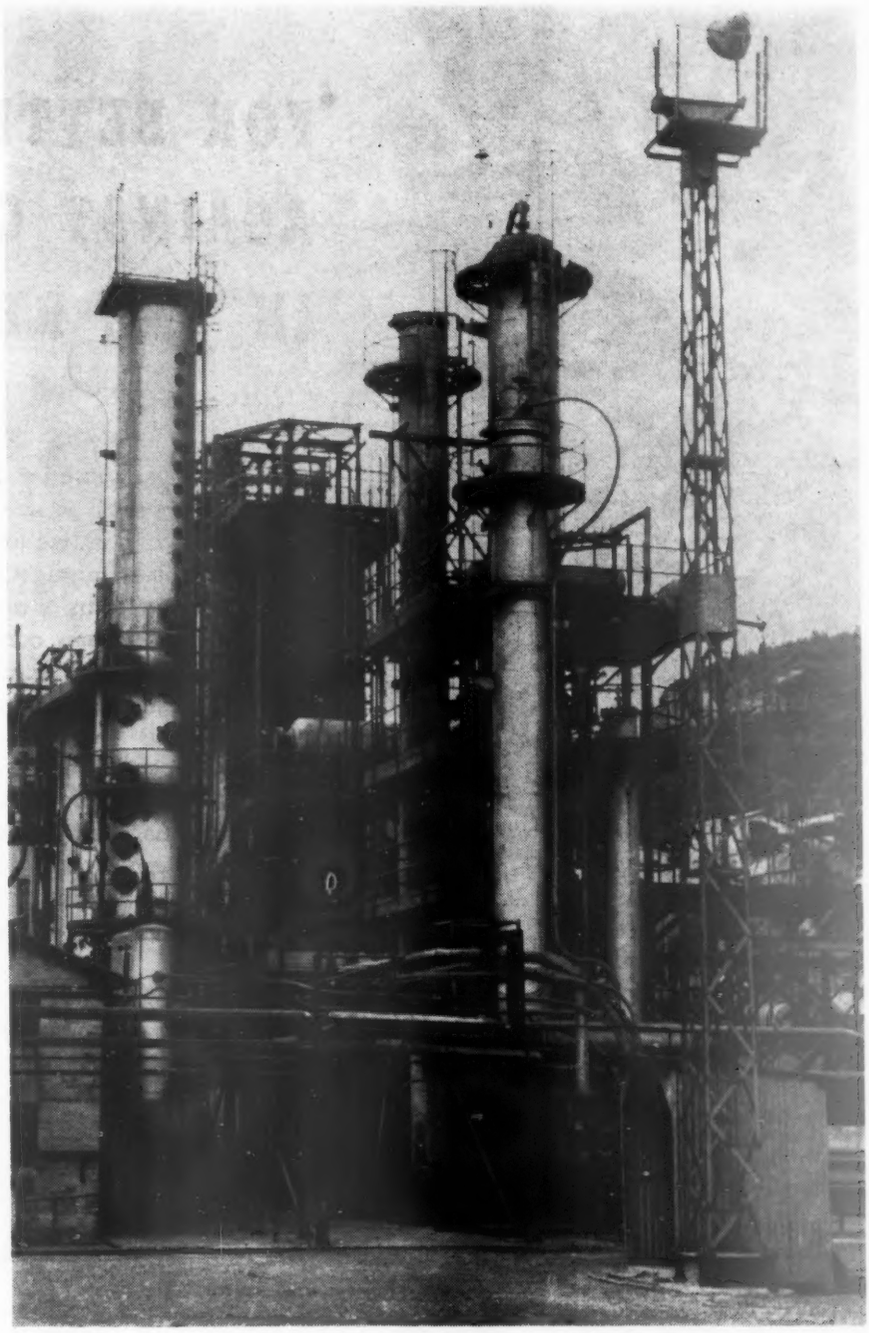
Boiling range	from approximately 300 F to 950 F (Vacuum distillation corrected to atmospheric pressure).
Sulfur content	0.60% S.
Nitrogen content	0.60% N.
Br. No. (Francis)	10
Aniline point	63 C
Pour point	15.5 C
Olefins	25-29 per cent, containing between 3-5% highly reactive hydrocarbons (diolefins, substituted coumarones and pyrroles)(including part of the sulfur compounds).
Normal paraffins	25 per cent
Isoparaffins	9 per cent
Naphthenes	15-17 per cent including part of the sulfur compounds.
Aromatics	20 per cent (including phenols and part of the sulfur compounds).

TABLE 13.

Specific gravity	0.860
Aniline point	67 C
Bromine No. (Francis)	1.5
Sulfur content	0.49%
Nitrogen content	0.16%
Color	greenish, fluorescent

TABLE 14.

Softening point	Semi-solid at room temperature
Solubility	Very soluble in acetone, methanol, and ethanol, slightly in chloroform or benzol insoluble in petrol ether, nheptane, alkali, acids, or water
Nitrogen content	1.4%
Sulfur content	0.77%
Color	glossy black



UOP polymerization unit in Glen-Davis. Coke chambers are in back.

If the crude oil is pretreated with 87[1] per cent H_2SO_4 or furfural it does not undergo the HCl reaction. The furfural extract of untreated crude oil after having been freed from furfural, however, gives a strong positive reaction. It has been reported that coumarone and indene can be selectively extracted from coal tar light oils with ethylene glycol, furfural or ethylene.diamine.[26] Coumarones are also easily polymerizable by the action of mineral acids. The solubility and ease of polymerization of this part of the crude oil indicates that coumarones in substituted form may be present. The relatively low nitrogen content of the precipitate indicates also the presence of traces of polymerized pyrroles* and insoluble hydrochloric acid salts of higher tar bases.

Some of the substituted higher olefins in the crude oil react so slowly (steric hindrances) that the Francis Bromine number determination does not completely detect them. A combination of the methods of sulfuric acid extraction[28] however, and the McIlhiney method[29] seems to give reasonable results.

A combination of the urea method[30] and chromatographic separations[31] permits the isolation of pure straight chain aliphatic hydrocarbons and the determination of their olefin content. The method of van Westen and van Nes[32] permits the determination of the naphthene and isoparaffin content.

Mapstone isolated approximately 9

*The presence of pyrroles and indoles in Australian shale oils has been reported.[27]

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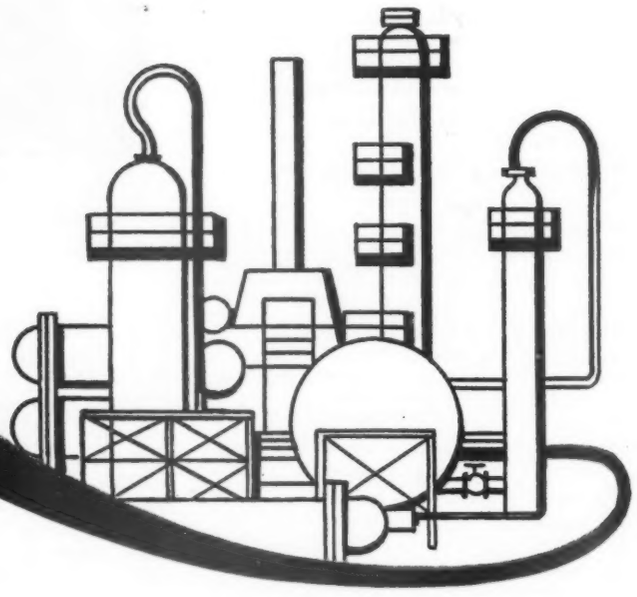

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to 10 per cent of paraffin wax[2] (determined by the UOP Method No. A-46-40) and recently a fraction of sulfur and nitrogen compounds have been selectively extracted together with aromatics.

The determination and isolation of the aromatic components was done by the combined application of chromatography and selective extraction with furfural. The aromatic component of crude shale oil extracted with furfural, however, contains up to 50 per cent of compounds, which are reactive with 87 per cent sulfuric acid and their bromine number indicates the presence of olefins.

The distribution of sulfur and nitrogen over several components of Glen Davis crude shale oil is shown by Table 15.

The possibility of the presence of a certain amount of polysubstituted aromatics, however, must be taken into consideration. It is known that such aromatic hydrocarbons, although not being olefins, give positive bromine numbers, and are very reactive towards the action of even 87 per cent sulfuric acid.[33]

By-products recovered on large scale.

(a) *Gases.*

The light hydrocarbons from the stabilizer overhead containing C_2 to C_4 olefins are charged, after a water wash, to a UOP polymerization unit.[34] After stabilization of the polymer gasoline, the remaining C_3 and C_4 hydrocarbons are stored in pressure vessels and are delivered later for distribution as bottle gases in the usual way. The gases that have passed the absorption column are used as fuel gases for the cracking and reforming units, a surplus being burned in a flare. An example of the average composition is given in Table 16.

Some pilot plant research work resulted in finding ways to utilize these flare gases for the manufacture of carbon black. It is obvious, however, that several other ways could also be developed for the utilization of these gases in the fields of petrochemistry, provided that higher output in the mine would give more shale oil to improve the economies.

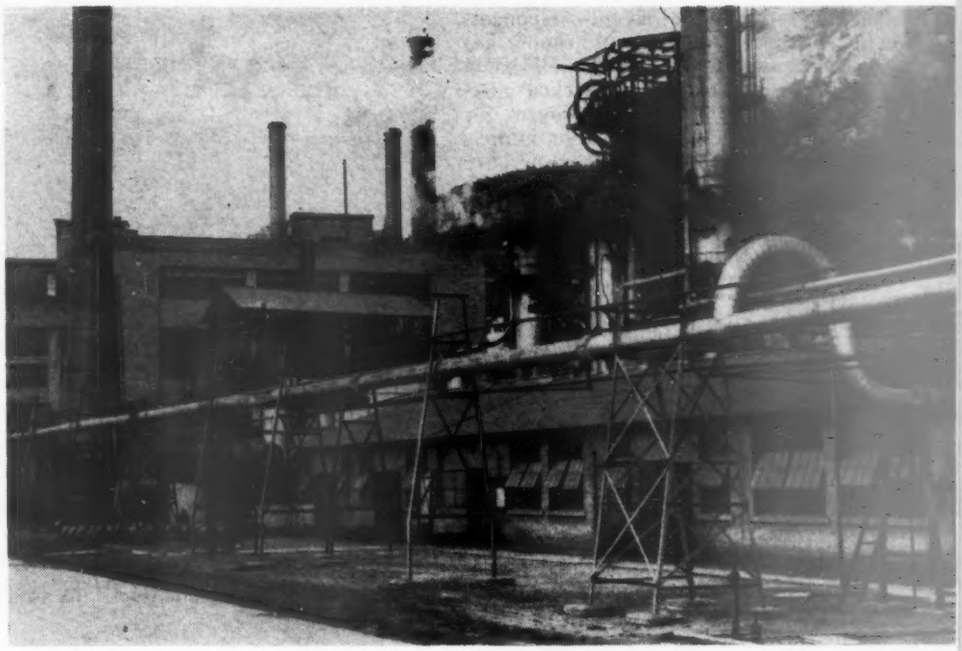
(b) *Cresylic Acids.*

Cresylic acids are recovered from the caustic wash liquors from several parts of the plant.[34]

It has been found by laboratory tests that the re-run bottoms of the acid-treated stabilized pressure distillate contains up to 8 per cent higher substituted phenols. If these products undergo a mild cracking operation it is possible to split off the side chains in the molecules of these higher substituted phenols and a remarkable yield of xylenols and cresylic acids occur when the cracked re-run bottoms are washed with caustic. This operation could double the output of cresylic acids from the whole plant,[22] if conditions would allow continued operation at Glen Davis. At the same time it has been found that higher substituted sulfur compounds crack to obviously lower substituted thiophenes which perhaps could be a source for pharmaceutically useful compounds.[22]

(c) *Coke.*

Most refinery runs had to produce coke and sometimes almost half of the available crude oil was used for this purpose. The quality of the coke was equivalent to the best coke manufactured from petroleum stocks elsewhere. Alumina and industries which manufacture special steels have used Glen Davis shale oil coke to advantage in test runs. In 1950 about 2200 tons of coke were produced.



Cracking plant.

By-Products Made On Pilot Plant or Laboratory Scale

Surface Active Compounds. Laboratory investigation has shown that sulfonation of the gas oil fraction of crude shale oil results in a good yield of surface active sulfonates.[30] The sulfonation of re-run bottoms, however, also gives promising results in this direction.[22]

Application of the "Reed re-action"[35] to H_2SO_4 pre-treated Glen Davis crude shale oil fractions (thus freed from olefins) of the boiling range 220-340 C gives, after saponification of the sulfochlorides with NaOH, excellent washing and foaming detergents that are equal to those obtained from synthetic Fischer Tropsch gas oils.[36] Laboratory tests also have shown that the great variety of useful derivative which can be obtained by reacting sulfochlorides with alcohols, phenols, ammonia, and other compounds[37] can easily be obtained from selected Australian shale oil cuts.

The alkylation of benzol with selected olefinic fractions of Glen Davis crude shale oil has also been tried with $AlCl_3$ catalyst. A good yield of products similar in their properties to alkylarylates was obtained. The sulfonation of these products gave surface active compounds with high emulsifying power.[f]

Weed K llers. Recycle light oil has been found to have strong weed killing properties. Especially when sprayed over an area infested with Bathurst burrs, paspalum and thistles the action was quick and thorough. A similar but somewhat weaker effect is obtained by the application of re-run bottoms.

Lubricants. After the first war the set-up of shale oil processing at the old Newnes works, which mined the same shale deposits as the Glen Davis enterprises approximately three miles to the north, was somewhat similar to the Scottish oil shale industry. Cuts of higher boiling range were used for the preparation of lubricants after dewaxing and acid and clay treatment.

Later on M. Pier[11] showed that Australian crude shale oils treated by high pressure hydrogenation methods gave very satisfactory yields of stocks that appeared to be comparable to those that are used for the manufacture of Pennsylvania lube oils.

As mentioned above, it was found lately that selected olefinic crude oil fractions of appropriate boiling range can be condensed in the usual way with benzol and naphthalene using an $AlCl_3$ catalyst. The resulting alkylation products give lube oils after vacuum distillation and clay treatment.

Chemical Possibilities. The content of olefins and substituted aromatic hydrocarbons in crude shale oils generally could make them an interesting source

TABLE 15.

	Aliphatic fraction	Naphthenic fraction	Aromatic fraction
%S	0.26	0.61	1.45
%N	0.19	0.40	1.58

TABLE 16.

	Per cent
Hydrogen	3.8
CH_4 to C_4H_{10}	78.5
Ethylene	4.73
Higher olefins	9.22
CO	3.46
H_2S	0.29
O_2	nil

[f] Further research with regard to this problem is planned.

for the separation of useful components for further syntheses. Mapstone has demonstrated the possibility of using tar bases extracted from cracked gasoline as octane number improvers for shale naphthas.[38] The corrosion inhibiting properties of shale tar bases have been studied by Mapstone and Mathews.[39] The manufacture of paraffin waxes in the old shale oil works at Newnes[4a] gave good results, considering the quality of the waxes.

Nitration of selected crude shale oil fractions in the laboratory seems to give products with approximately two nitro groups per one average molecule of the oil fraction. The possibilities of nitration of shale oil fractions are very interesting and are still under investigation. As was to be expected, the saturated aliphatic part of crude shale oil reacts similarly to Fischer Tropsch paraffins. Paraffins extracted from crude Glen Davis oil by the urea method[40] after purification from straight chain olefins, reacted similarly on nitration to those treated with HNO_3, by Grundmann.[41]

Asphalt. Pilot plant research aiming to manufacture road asphalt from Glen Davis cracking residues gave some encouraging results; however, the series of tests to improve some of the properties up to required specifications have not been finished. It appears that crude shale oil or mixtures containing crude shale oils would give still better results. Further research in this direction would certainly be warranted.

Conclusions

Considering various possibilities for the use of the high-grade Australian oil shales it appears that the manufacture of gasoline is perhaps not the most advantageous solution for their economic use at present. It is rather possible that the utilization of these high-grade oil shales for the manufacture of raw products for the chemical industries, using petrol production only as an outlet for lower grade fractions or residues to be cracked or hydrogenated, would perhaps be one of the methods that could help to overcome part of the economic difficulties of the present set-up of shale oil manufacture in Australia.

One of the key factors for the future economic oil shale exploration in Australia still remains to be solved, namely, the problem of mining the low main seams of high-grade oil shale at much lower costs than is possible at the present time due to circumstances on the 5th continent.

View of cracking plant from tank farm.

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★ ★ ★

AIOC Refineries to Produce 40 Per Cent of UK Output

By early next year Anglo-Iranian Oil Company's four refineries in Britain will be turning out 211,000 bbl of the country's entire daily production of 530,000 bbl, according to a recent article in London's oil magazine, "The Petroleum Times." Estimates of Europe's 1952-53 refining capacity made a year ago by the Organization for European Economic Cooperation are already completely out of date with regard to Britain, the article states. OEEC calculated the combined throughput capacity of British refineries would be about 426,000 bbl a day. This figure has been surpassed already and by 1953 the actual total of rated capacity will be something like 530,000 bbl a day. The magazines points out that further increases planned for the near future will bring Britain's refining capacity up to 560,000 bbl a day, over 11 times what it was 5 years ago.

Anglo-Iranian's Kent refinery, originally intended to have a capacity of 40,000 bbl a day will process 80,000 bbl. The capacity of Llandarcy (South Wales) has been boosted to 80,000 bbl a day. The present 47,300-bbl capacity of Grangemouth refinery exceeds OEEC estimates by nearly 20,000 bbl a day.

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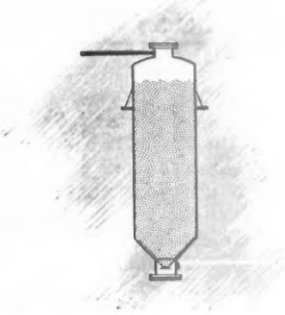

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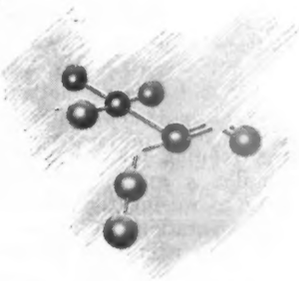

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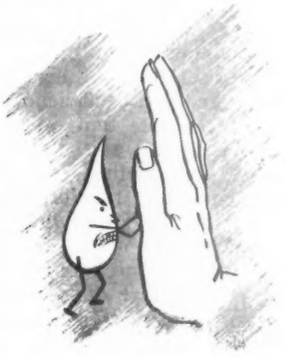

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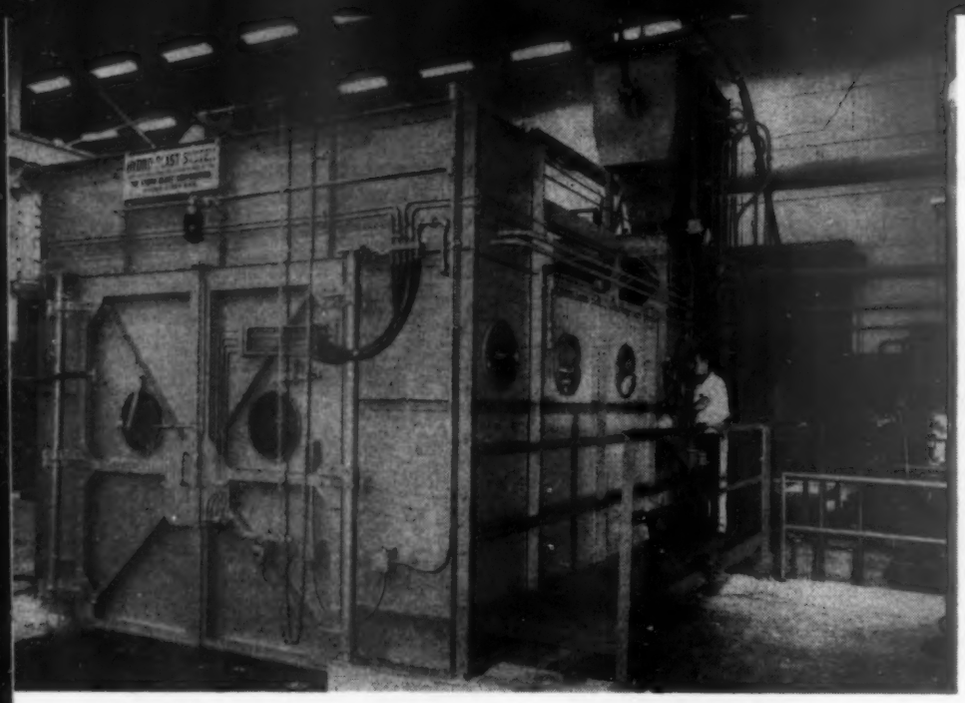


FIG. 1. View of cleaning "room" and working accessories, with single operator at controls. Control box is movable back and forth the entire length of the room. Note sand line passing upward from the sand pump, extreme right, to the box above the room; also, the set of hydraulic lines to the control on front door and hoist chain, which together control movements of the end gun.

EXCLUSIVE

New "Jet" Exchanger Cleaning Method

Methods are of paramount importance in maintenance of efficiency and throughput

ARCH L. FOSTER*

As refining operations become more complex a greater attention is being given to raising the efficiency level of plant operations. A greater number of heat exchangers are installed for any given process or unit. A greater amount of heat is being "recirculated' in the refinery, to effect conservation of fuel, of heat energy.

The usefulness of heat exchange is determined by the efficiency of the process, of the rate and quantity of heat transferred per unit of theoretical capacity. Thus methods for the improvement of heat transfer efficiency are among the matters of most importance to the refinery operators, all the way from rank of unit foreman to chief executive in charge of manufacturing.

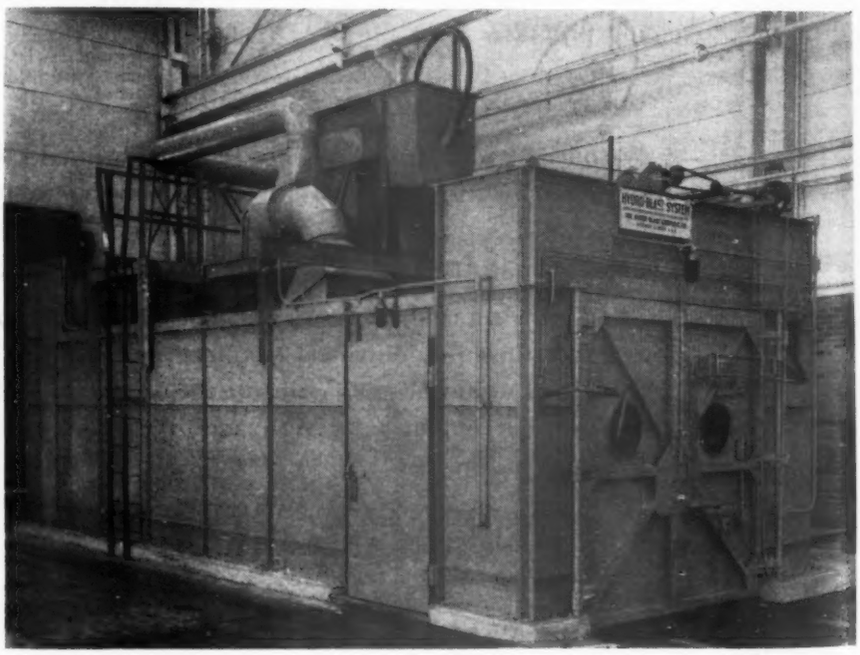
Heat exchangers' efficiencies are determined largely by two factors—the design of the exchanger, including metals employed and the initial transfer rate "built into" the exchanger, and the degree to which this efficiency is maintained by the operators. And maintenance of the exchanger efficiency depends largely on the degree of cleanliness maintained within it and thus the maintenance of the original maximum heat transfer rate.

Therefore the cleaning of heat exchangers and methods for accomplishing this end are of paramount importance in maintenance of heat exchange efficiency and of throughput in the refinery. Of the several methods employed for this purpose, the newest and one of the most efficient is that developed recently by Hydro-Blast Corporation, and purchased and operated under large-scale plant conditions by Esso Standard Oil Company at its Baton Rouge, Louisiana, refinery.

This method takes advantage of the water-sand blast principle to remove deposits of practically any nature, found on any surface of a heat exchange unit. Sand is employed because of its small-particle cutting effect in loosening deposits piecemeal from the surface being cleaned, without the objectionable degree of abrasive action that would be sustained by the use of sharper, heavier agents such as emery or carborundum, with resultant damage to clean metal surfaces. Water is used as a carrier, as supplying a cushioning effect on the sand blast to reduce further the detrimental cutting effect of the sand on clean metal, and even more as a means of washing or sweeping away the deposit material once it is loosened from its attachment to the metal surface.

Originally the primary principle of this cleaning method was developed to clean the surfaces of metal castings and other products from metal preparation and fabrication mills, an undesirable coating produced by an entirely different operation but equally deleterious to the utilization of the primary product. Its adaptation to the purposes of oil refining came as a result of the realization that it offers advantages not shown by any other method, in like degree. The new system removes practically any type

FIG. 2. Side view of cleaner, showing entrance door, ladder, blower, and exit duct.



*Editor, Refining and Gas Processing.

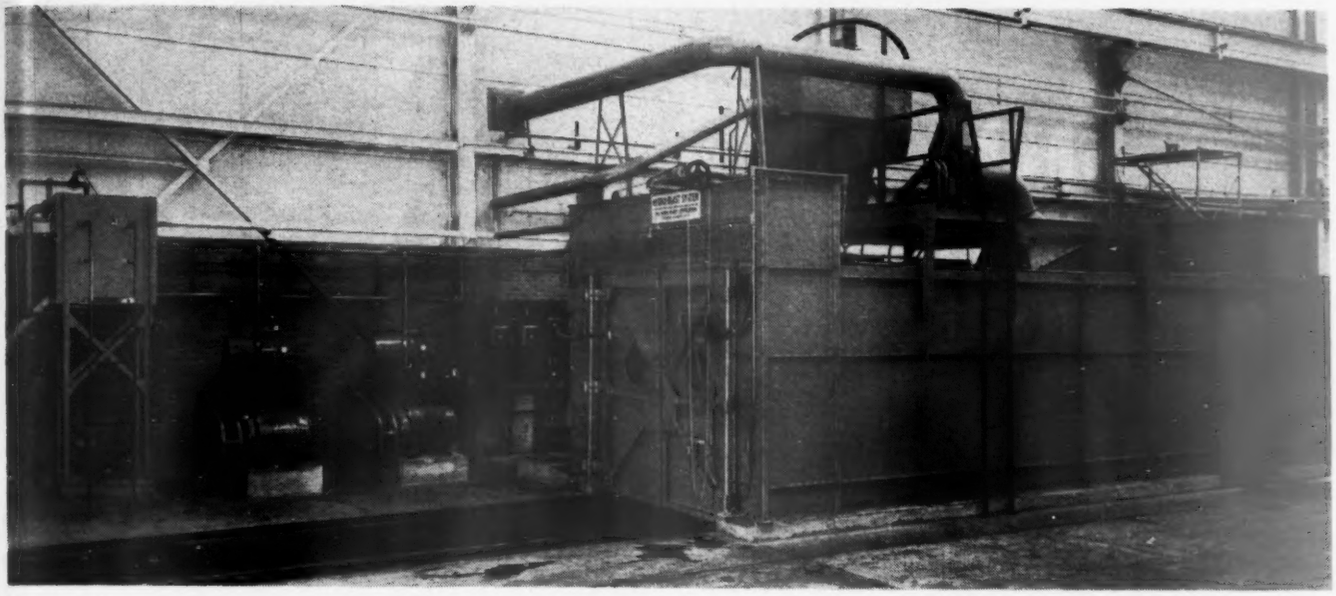


FIG. 3. Water surge tank, left, two water pumps, and switch boxes. Fresh sand supply is added through grating in floor.

of deposit or foreign material, directly and without other aid. As shown later, some bituminous or rubbery waste products are not removed completely, but must be removed by scraping or more commonly by solvent action, before the last traces are eliminated along with less difficult deposits.

The system is built around a compartment or "room," in this instance a totally enclosed 30-ft by 11-ft, by 8-ft in height, built of structural steel sections, of ¼-in. carbon steel bolted together. Two 8-ft by 8-ft double doors are provided at each end, also of steel sheet, with a side access door 3-ft by 6-ft, 8-in., which permits entry to and exit from the "room" without opening the end doors.

Twelve observation ports are provided 8-in. wall on operator's side and one each in the four end doors, through which operations inside can be observed by the operator. The frames of the windows are of bronze, the glass is of double strength, double thickness. On the outside, next to the operator the glass is safety type. Inside is another sheet of plain, relatively inexpensive glass, easily replaceable if the wear and tear of sand and water damages it or makes it gradually opaque and thus hinders observation. In this way the expensive safety glass is protected at minimum cost. Water jets are placed to clean the glasses from inside if sand and water obscure observation.

The sand tank, (Fig. 1), receives the sand-and-water slurry that is fed to the blast nozzles inside the room, the top of this tank being some 11 ft above the floor level. Six special, 500-watt marine type flood lamps are installed to illuminate the work during operations. These lights are partially visible in Fig. 4, and are so placed as to be out of the direct path of the jets and yet to illuminate all parts of the work except that underneath and hidden by the body of the work in any case.

Fig. 2 shows the surge tank or hopper above, with the sand inlet line coming up and over from the opposite side. In the foreground just in front of the hopper, is the suction fan and duct for removing gases and vapors from the blast room. A ladder to permit inspection of and work on these items is shown at left, Fig. 2. Fig. 3 shows the two special Worthington Triplex high-pressure pumps (left, against brick wall), each of which has a capacity of 30 gal per minute at 1600 psig, feeding water directly to the blast nozzles. The surge tank for incoming water, on which the pumps take suction (far left, Fig. 3), is 2½-ft by 3½-ft by 4-ft, to which the inlet water line is direct-connected. The pump motors operate on 440 volt A-C, at 885 rpm. The Nagle sand pump is a 2-in. Type SWB, supplying 140 lb of river sand per minute, direct-connected to a 3-hp motor and operating at 1200 rpm. The grated floor in front of the pumps, Fig. 3, has a sluiceway opening below it, and sand is dumped onto this grating, washed down into the sand pit by a water hose when sand is to be added.

Fig. 4 shows an inside view of the room with lights, windows and hose connections to the nozzles, one at the side and one at the opposite end of the room. The hose shown is 1-in. diameter, of rubber and cotton, one conveying

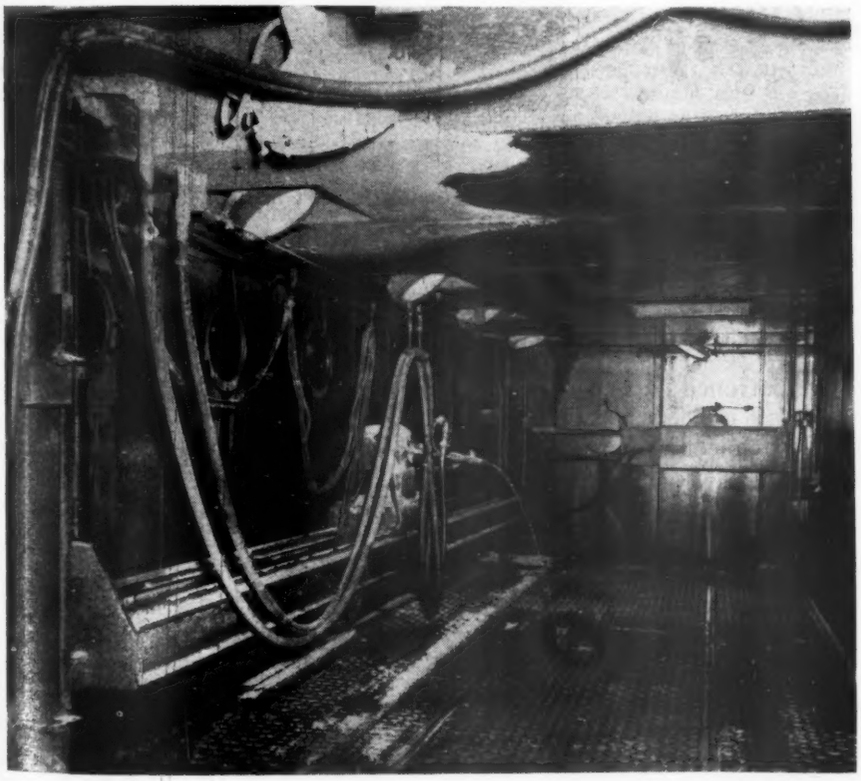


FIG. 4. Side gun is mounted in its dolly, left center, showing sand and water lines leading to nozzle and slow stream of water exiting from nozzle.

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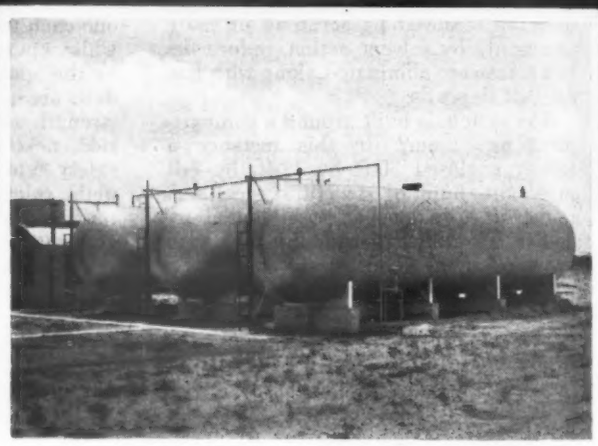

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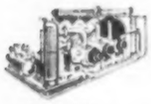

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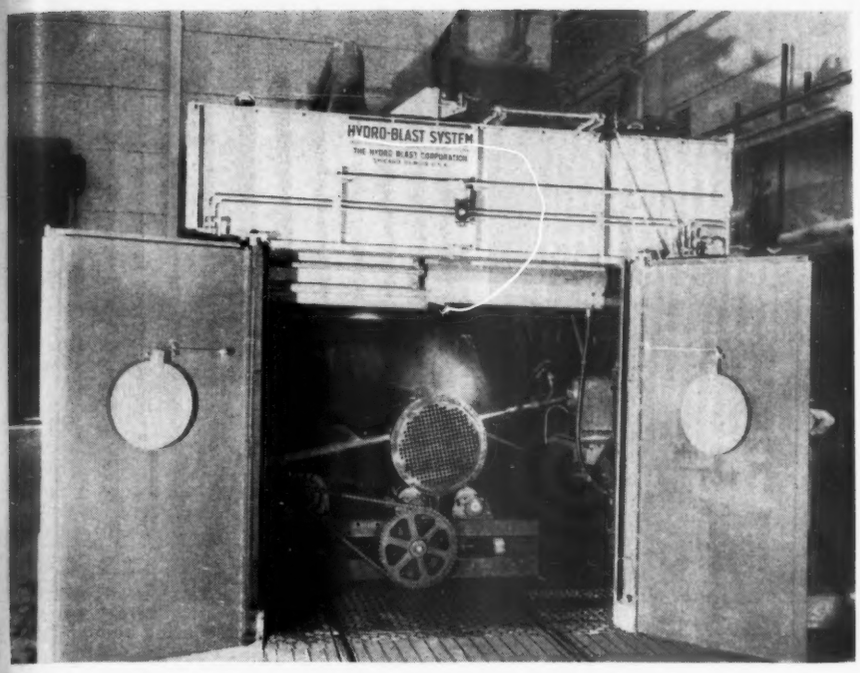


FIG. 5. Exchanger bundle in position and side gun jet in operation, at 1500 psig. Motor and chain-and-sprocket arrangement for turning bundle on rollers is shown in foreground.

sand and the other water to the nozzle. Each nozzle projects into the room a short distance, the housing is of bronze. In construction the nozzle is arranged to admit water in a direct line with the nozzle jet's exit; sand is sent into the nozzle housing at right angles to the jet, and is picked up by the venturi-action of the water stream, and projected through a restricting nozzle or throat. Experience has shown that this venturi or restricting throat item gives the best results and the longest life when made of boron carbide, of any material yet tried. With this arrangement the sand is not in contact with the mechanism but a very short distance when under high velocity and pressure, thus minimizing wear and erosive effects.

The carriage dolly handling the side nozzle, as shown, moves back and forth on horizontal rails along the side wall, by electric motor; the horizontal rail assembly is raised and lowered as a unit, up and down the side wall to give the required double motion to position the jet as needed. In addition, a hydraulic mechanism in the head of the "dolly" (holding the nozzle) enables the operator to move the nozzle and thus the jet in a cone movement as desired for proper cleaning action. The end gun uses a mechanical hoist to obtain vertical motion of its carriage or "dolly;" for horizontal motion a hydraulic system is installed, operated manually from outside. When opening the unit, the end guns are hoisted up into the extended end sections, seen in Figs. 2 and 3.

Equipment is brought into the room by first being loaded onto a work car or flat car, running on the narrow steel tracks shown, Figs. 1-5. An end view of this work car is shown in Fig. 5. It is of steel construction, channel sections welded as shown, and is equipped with two sets of rollers spaced as seen in Fig. 5, one pair of short rollers, front, and a second set of long rollers in rear. These rollers can move nearer together or farther apart to accommodate bundles or objects of different diameters. The left-hand rollers (Fig. 5) are attached to metal plates drilled for pins; the cross I-beams of the car are also drilled with 1 1/16-in. holes at different intervals (see foreground, Fig. 5) and pins are passed through these two sets of holes to retain the rollers at the required distance apart to hold the work.

The motor shown on the front end of the work car operates the rolls by sprocket and chain as seen, the drive shaft turning each set of rollers, to rotate the work as required, through a reduction gear. The work car incidentally, is mounted on six flanged wheels as supports.

The control center from which all side gun, work car roller, and observation port water spray operations of the system are directed is shown near the middle of the side wall, Fig. 1, with the operator on the job. This box is movable back and forth the entire length of the room, enabling the operator to assume the position nearest to the position of the jet while in operation. Small water lines are led to the top element of the observation ports through which a stream of water is released at the will of the operator, to clean the ports of water and sand which obscures vision on occasion. To the right of the operator in this picture also is the sand slurry pit, below the floor level, with the sand pump motor and vertical drive shaft seen, extreme right; from the bottom of the sand pit the heavy black sand hose is shown passing upward and entering the sand feed tank above. Note that all sharp or short bends are avoided in this line, to minimize abrasion on the hose.

Early experience showed that the wet sand has a tendency to pack in the sump, and that the sand pump will fail to pick up a proper amount unless this packing is prevented. Therefore an air system was installed to give agitation and keep the sand more or less in suspension until the pump can pick it up to return to the system. This new idea works satisfactorily.

It has been found also that erosion of the sand pump is fairly high. A new, rubber-lined pump is in process of procurement, which will use a 7½-hp motor, and is expected to reduce erosion to a minimum. Chiksan swivel joints are employed on the water lines. The high pressure water hoses to the side guns are 1-in. internal diameter and 25 ft long, in this unit. Water hoses for the end guns are ¾-in. by 14-ft, and ¾-in. by 11-ft. Sand hose in one instance is 1-in. by 30-ft, in the other is ¾-in. by 35-ft.

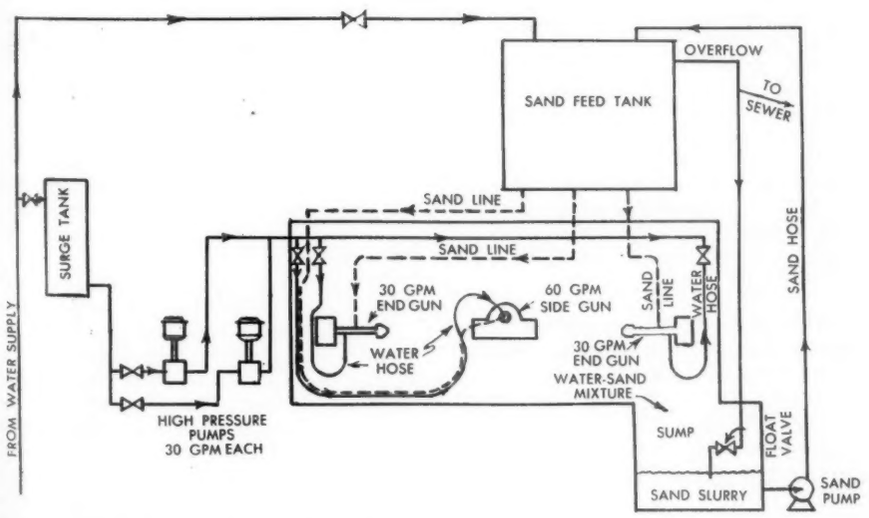


FIG. 6. Drawing shows main units and circuits employed in cleaning system.

Cleaning Operation

A heat exchanger bundle to be cleaned is lifted via crane to the cradle on the carriage and the carriage is pushed, generally by forklift truck into the cleaning room. The end gun assembly just inside the entrance door is lifted overhead and out of the way. When the

laden carriage is inside the room the work is rotated so that the water-sand jet passes directly between two adjacent rows of tubes, in whatever position, up or down, it may be. This "straight through" position of the rows of tubes and the jet gives the best results. Cleaning is also better with this arrangement than in bundles having staggered rows of tubes. Fig. 5 shows that the jet passes entirely through the bundle.

Incidentally, an "air tugger" may be used to draw the carriage into the room. by taking a hitch on the opposite end of the room. At present a built-in system is being devised to handle the movements of the carriage.

One operator handles the entire cleaning job, but has the help of other workmen to get the work into position. If tubes are stopped completely a hole is drilled through their length, as at least a small opening must exist, or no cutting effect is obtained.

The bundle is rotated in any desired degree to set the lines of tubes parallel to the jet stream. To rotate the bundle, the electric motor on the carriage turns one roller of each pair in the same direction, through two gears. Then the operator positions the side gun, for example, opposite a given set of tubes, and turns on the sand and water streams, the two water pumps supplying 30 gal of water per minute each. The ratio of sand to water is maintained by the suction force of the water entering the jet nozzle and is not predetermined by any separate control. Gradually the jet is moved down the length of the bundle and at the opposite end is lowered or raised to an uncleaned line of tubes and its forward direction is reversed. This operation is continued until the outside of the tubes has been cleaned satisfactorily. The bundle is rotated if need be to clean off any surfaces not cleaned properly by the earlier jetting.

When the outside of the tubes, and the tube sheets' edges are cleaned, the side gun is cut out of action, and the end guns are brought into play, being maneuvered into position by means of the chain hoist, and the hydraulic mechanism. The chain of the hoist and the assembly of four main lines in the hydraulic unit are seen best on the right side of the front door, Fig. 2. The end guns "shoot" straight ahead, are movable in two dimensions, up and down and left and right, but cannot now be rotated in a cone-shaped jet arrangement. The jet is moved back and forth, up and down, in a manner similar to that travelled by the side gun to clean the inside of the tubes and the face of the tube sheet. The stream of water, sand, and removed material jets from the opposite end of the tubes. If the gun at one end leaves something to be removed at the opposite end, the gun at that end is brought into play to finish the inside cleaning job. Plans are under way by the designers, it is understood, to perfect an end gun that has the rotatory, cone-form motion that now only the side gun has.

Experience has shown that while the end guns will clean under a wide variety of conditions, the specific condition of the tubes may call for variation in the method of handling the end gun. In general, however, it is found that this gun cleans best when set with the front end of the nozzle about one inch away from the end of the tubes. Customarily this is the gap maintained in normal cleaning operations. The water and sand from the blast fall to the floor of the room and drain back into the sand pit as shown in the drawing, Fig. 6.

FIG. 7. View of typical foul bundle before cleaning, and

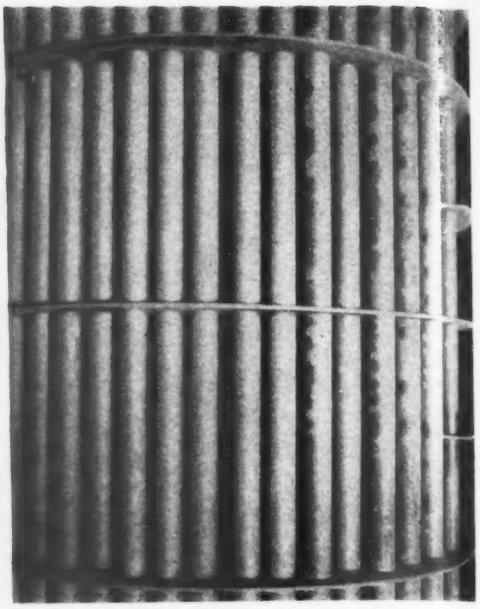


FIG. 8. The same bundle after being cleaned by this method.

A typical example of efficient cleaning is presented in Figs. 7 and 8, which show, respectively, a fouled tube bundle before and after the cleaning operation. Inspection of several bundles tubed with steel, Admiralty, brass, etc., indicates that little if any erosion occurs on the clean metal and the life of tubes is not affected adversely by the blasting operation.

Difficulty is experienced in removing, asphaltic, or tarry deposits from metal surfaces, and it has been found more useful to remove such organic materials by the use of solvents, either before or after blasting. It appears more profitable to dissolve tarry materials first and blast afterward.

Some data have been collected to show the relative rates of heat transfer through the same and through different bundles before and after blasting. The accompanying table shows results obtained by three different cleaning methods: (1) mechanical cleaning, as with brush and scraper; (2) chemical cleaning, with reagents and/or solvents, and (3) Hydroblasting.

TABLE 1. Comparative heat transfer ratings on exchanger bundles cleaned by three Btu/hr/square feet F.

	Mechanical		Chemical		Hydroblast	
	Before	After	Before	After	Before	After
(1).....	8.0	18.0	.....	.....	8.0	22.0
(2).....	47.0	99.0	49.0	109.0	.....	.....
(3).....	.....	.....	33.0	76.0	12.0	65.0
(4).....	112.0	180.0	124.0	453.0	.....	.....
(5).....	.....	.....	46.0	82.0	54.0	94.0

In the first instance mechanical cleaning was compared with Hydroblasting, the latter showing an increase of heat transfer rating from 8 to 22, whereas mechanical methods raised the rating only to 18. Chemical cleaning showed improvement over the mechanical method, raising the rating of another bundle from 49 to 109, whereas the mechanical routine raised it to only 99. In another instance chemical cleaning raised a rating on dirty tubes, from 33 to 76; Hydroblasting boosted a 12 rating to 65. In the fifth instance the rating improvement was approximately the same by these two methods. All these ratings are in Btu per hour per square foot per degree F difference in temperature. Obviously the same bundle could not be tested always by two methods in the same instance but the same bundles or similar bundles were tested by the different processes.

As to cost and savings in these methods, a bundle can be cleaned by the Hydroblast routine by one man in about half the time that three or four men can clean it by scraping and brushing, conventional mechanical methods. No conclusive data are available yet on comparative speeds and time costs as compared to chemical cleaning; however, the time in man-hours compared to mechanical cleaning is about one-sixth to one-eighth, according to the engineers who have developed and operated the new method.

Many other types of equipment may be cleaned by this method, in fact anything that can be brought into the room can be cleaned. The writer observed the rapid cleaning of the two "halves" of an electric motor housing, which were merely placed in the grating floor of the room and blasted directly, it being necessary to open the door and change the position of the work by hand to complete the job, which required only a few minutes overall. ★ ★ ★

Determination of Per Cent Voids Filled in Roofing

C. E. WILKINSON*

In the manufacture of asphalt prepared roofing, a continuous sheet of felt is impregnated by drawing it through a vessel containing hot, liquid asphalt saturant, maintained at a temperature of approximately 425 F. This step is followed by the application of a film of a more viscous coating asphalt to both sides of the saturated sheet. Granular materials and/or talc or flake mica are then embedded in the coating films to give the finished product.

High-grade felts, which are sufficiently porous to permit maximum absorption of saturant, are necessary for the manufacture of superior roofing. The saturant must possess properties such that it will readily penetrate and coat each fiber of the felt and fill the spaces (voids) between the fibers as completely as possible. The roofing industry has recognized for some time that, for asphalt prepared roofings to be resistant to blistering when subjected to atmospheric weathering, the felt must be highly impregnated with the asphalt.

Several procedures for determining the extent to which felt is impregnated have been designed for use by the industry. The most widely used of these is the per cent saturation test.[1] By this method a piece of saturated felt is cut to a convenient size and weighed. It is then extracted, using benzene, carbon tetrachloride, or any other suitable solvent. The extracted felt is dried and then weighed. The weight of the saturant is determined by difference and the per cent saturation is calculated from the formula:

$$P = \frac{sf\text{-}f}{f} \times 100$$

where P = per cent saturation
sf = weight of saturated felt
f = weight of dry (extracted) felt

The above procedure for evaluating the extent to which felt is filled with asphalt has the following disadvantages:

1. Low reproducibility resulting from non-uniformity of felt and losses during the extraction process.
2. Time consuming.
3. Results can be misleading. High per cent saturation values may be obtained by the test, which would indicate that the felt had been satisfactorily impregnated with asphalt. White unsaturated spots, however, may be revealed when the saturated felt is torn open, showing that the saturation process was not efficient in that the voids in the felt were not properly filled with asphalt.

Another procedure that gained wide usage for determining the extent to which felt is impregnated with asphalt is the Manufacturing and Industrial Research Committee method for determining per cent voids filled. By this method six 1 by 2.5-in. samples of saturated felt are weighed and immersed in amyl alcohol in a 600 cc beaker and subjected to a 28-in. mercury vacuum in a bell jar for 15 min. The samples are removed from the amyl alcohol and drained for 3 min ± 1 sec and again weighed. They are then desaturated and the dry felt weight determined. The per cent voids filled is calculated from the formula:

$$V = \frac{a}{a + \left(b \frac{c}{d}\right)} \times 100$$

where V = per cent voids filled
a = asphalt absorbed by dry felt
b = weight of amyl alcohol absorbed
c = specific gravity at 77 F of saturating asphalt
d = specific gravity at 77 F of amyl alcohol

Although this method is a more accurate procedure for evaluating the extent of saturation of felt than the per cent saturation test, it has certain disadvantages, namely:

1. Toxicity of amyl alcohol vapors.
2. Difficulty of obtaining proper draining of amyl alcohol from test samples.
3. Test is tedious and time-consuming.
4. Coefficient of expansion of amyl alcohol is high, requiring careful control of temperature throughout the period of testing.
5. Values obtained are lower than actual per cent voids filled because of a film of amyl alcohol remaining on saturated felt after draining. To compensate for this, a correction factor has to be applied.

To overcome the disadvantages mentioned in the methods described above, an apparatus and procedure have been developed for determining the per cent voids filled in roofing felt after saturation. This method is described below.

Apparatus

The apparatus consists of two glass cylindrical sections joined together with a flat ground glass joint (Fig. 1). The lower section tapers off, ending in a large tube fitted with a stopcock that permits rapid filling of the apparatus from the bottom. The upper part extends into a graduated tube with an expansion bulb near the top. Four projections are spaced equi-distant around the top and bottom sections to allow fastening them together with rubber bands. A wire basket is used in the lower section for holding the saturated felt sample away from the walls of the cylinder and thus permit air bubbles to escape more freely during the test. The apparatus is mounted on a ring stand, or suitable support, and the lower section connected to a siphon bottle by means of a rubber tube. The bottle contains water in which a small amount (0.1 gram/liter) of sodium oleate has been added. This soap solution should be evaluated under 28 in. mercury before using to eliminate any occluded air.

TABLE 1—Per cent voids filled data comparison with M. & I. R. results.

Sample[1]	Per Cent Voids Filled	M. & I. R. Per Cent VoidsFilled Corr.[2]	Theoretical Per Cent Voids Filled[4]
24-R[3]	92	91	91
30-R	82	79	95
40-R	78	79	82
50-R	79	79	89
57-R	82	81	87
50-S	79	78	84
73-S	67	69	76
Average	80	79	86

[1] Average of two results for the first sample, average of three results for the remaining samples.
[2] Correction applied to take care of film of amyl alcohol that remained on saturated felt samples after draining.
[3] The numbers 24, 30, 40, etc., represent felt numbers (lb/480 sq ft). The letters R and S represent roll and shingle saturants respectively.
[4] Based on the kersosine absorption test, and is equivalent to the ratio of the per cent saturation to kerosine absorption times 100.

Procedure

A sample 2.5 by 6-in. is cut from the saturated felt to be tested and weighed to the nearest 0.1 gram. It is then placed in the wire basket, without folding, and set in the lower section of the assembly. A thin film of stopcock grease is applied to the ground glass joint and the two sections are pressed together firmly, thereby insuring a perfect seal at the joint. Rubber bands are used for holding the sections together. The stopcock is opened and the siphon bottle elevated to a position above the assembly to permit rapid filling of the cylinder with the dilute soap solution. When the liquid reaches high into the graduated portion of the assembly, the stopcock is closed and the liquid level is recorded. The upper end of the apparatus is connected to a vacuum pump and the sample is evacuated at 28 in. of mercury for two minutes. The assembly is jarred at intervals of 20 sec during the evacuation period to remove any air bubbles that cling to the surface of the sample. The vacuum is released and the assembly is allowed to stand at atmospheric pressure for three minutes. The

*The Texas Company, Port Neches, Texas.

liquid level is again observed and recorded. The difference between the two recorded readings represents the volume of soap solution absorbed by the sample during evacuation, and indicates the additional volume of saturant that could have been absorbed by the felt. The per cent voids filled can then be calculated using the following formula:

$$V = \frac{s}{s + w} \times 100$$

where V = per cent voids filled
s = volume of saturant in ml
w = volume of soap solution absorbed by the sample in ml.

In making calculations using the above formula, satisfactory accuracy will be obtained under the following assumptions:

1. Between values of 0.950 and 1.050 at 77 F, the specific gravity of the saturant may be considered as unity, making the volume of the asphalt numerically equal to the weight in grams.

2. The specific gravity of the dilute soap solution may be considered as unity, making its volume numerically equal to the weight in grams.

3. When the felt number (pounds per 480 sq ft) is known within ± 3 units, the weight of saturant may be found by subtracting 1/10 of the felt number from the weight in grams of the particular 2.5 by 6-in. sample of saturated felt used in the test, since 1/10 of the felt number (pounds per 480 sq ft) closely approximates the weight of a 2.5 by 6-in. dry felt sample in grams. If the felt number is not known within ± 3 units, it must be determined within the required accuracy.

4. The test may be conducted at room temperature without making corrections, providing the temperature does not vary appreciably during the test.

Under normal conditions the average of two determinations are reported to the nearest whole number as the per cent voids filled for the saturated felt being tested.

Discussion

Table 1 gives data obtained by the above described method and the M. & I. R. procedure, as well as the calculated per cent voids filled values based on the kerosine absorption test. This latter test is usually made on the dry felt at the felt mill, and indicates the theoretical maximum per cent asphalt saturation possible for that particular grade of felt. The ratio of the actual per cent saturation of the saturated felt to the kerosine absorption value times 100 gives a theoretical value for per cent voids filled. The data show a close correlation of the results obtained by the procedure described above and the M. & I. R. method, but there is not close agreement with the calculated results except for the very thin No. 24 felt. The lack of correlation can be attributed to the disadvantages listed above concerning the per cent saturation test, and to similar faults encountered in the kerosine absorption test.

The proposed method is also applicable for determining the per cent

FIG. 1. Apparatus for determining per cent voids filled.

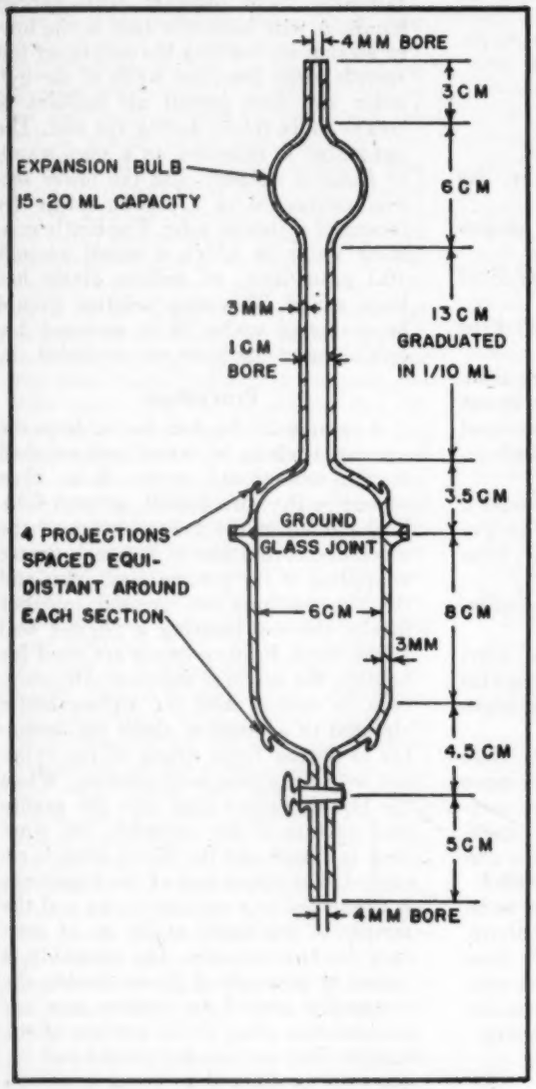
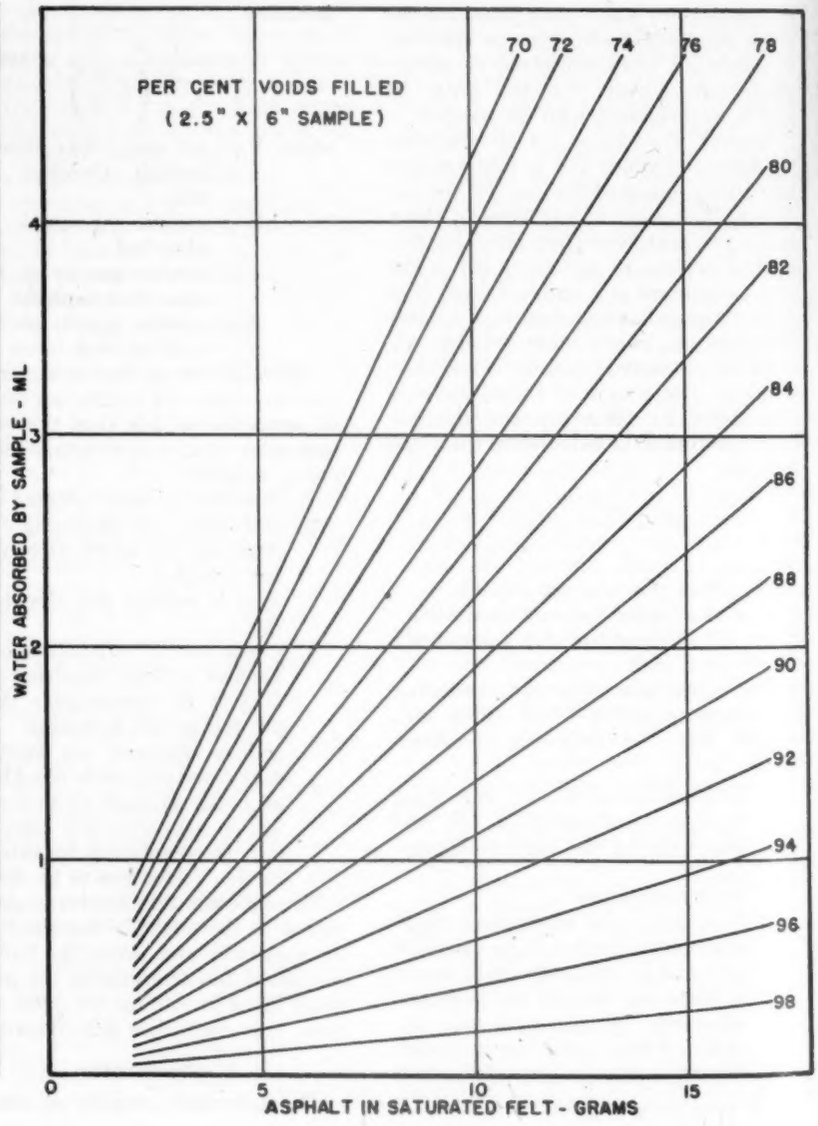
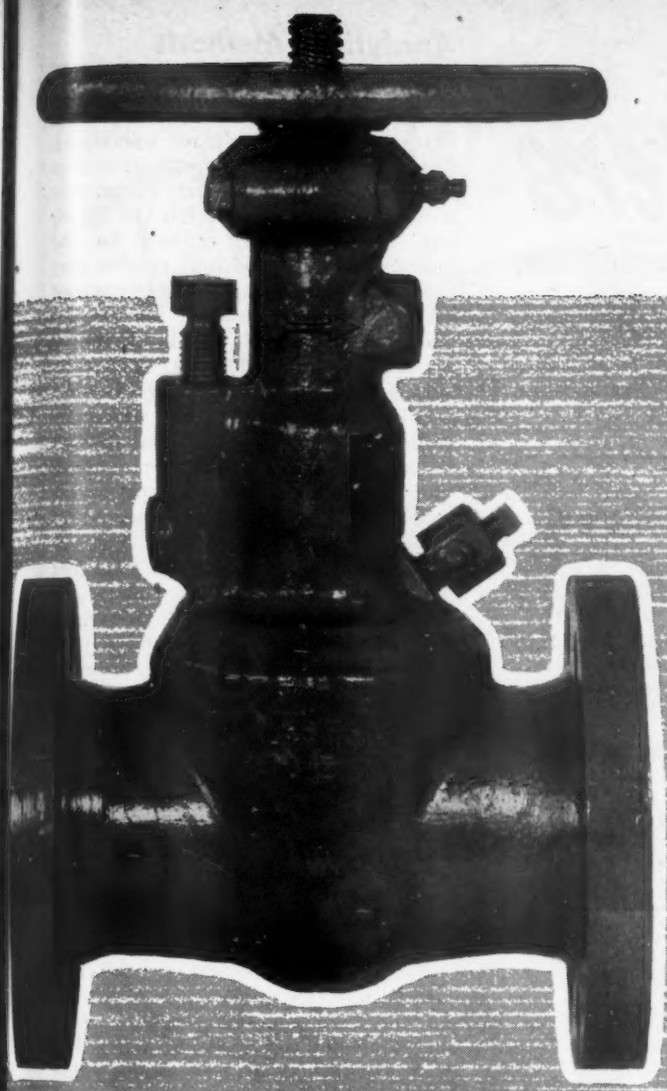


FIG. 2. Chart for estimating per cent voids filled.





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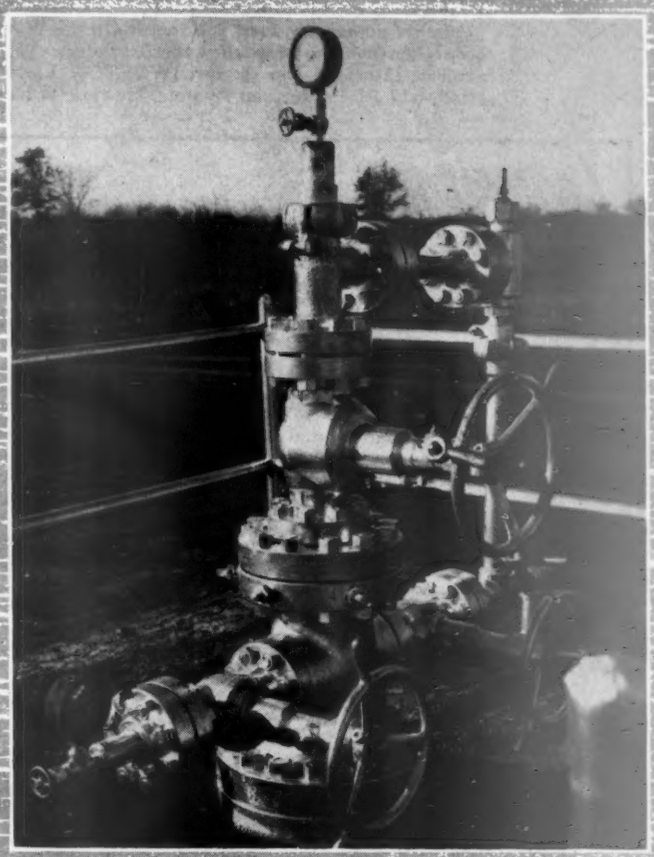

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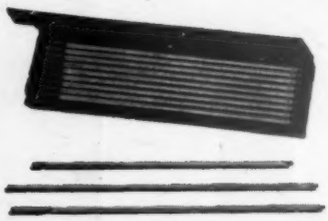

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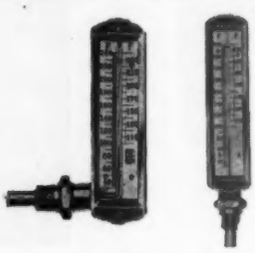

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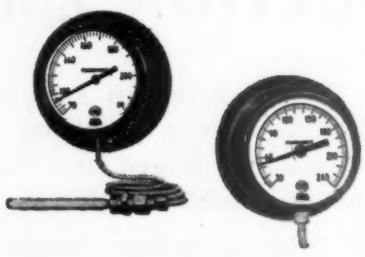

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9413

Analytical Methods

voids filled in finished roofings and may be used as a routine check on the saturation efficiency of plant operations. The same procedure is followed as that employed for saturated felt except that it is not necessary to weigh the 2.5 by 6-in. roofing sample utilized for the test. Sufficiently accurate results may be obtained by using a predetermined average weight of saturant for the particular grade of felt employed in the finished roofing under test. It is common practice in the industry to use a definite weight felt for each particular grade of roofing produced, but if there is any doubt concerning the approximate felt number, its value must be determined analytically to the required accuracy.

A chart (Fig. 2) has been prepared to facilitate the obtaining of results when the dry felt number of the membrane utilized in the saturated felt or finished roofing and the average weight of saturant in a 2.5 by 6-in. sample are known. The volumes of water absorbed by the samples during the test are plotted on the ordinate versus the weights of asphalt in the felts along the abscissa, giving parameters from which the per cent voids filled may be readily obtained.

Summary

This method for determining the per cent voids filled in saturated felt and finished roofing has been used for checking the saturation efficiency of plant operations for a number of years. Results obtained have also been of value in indicating the relative resistance of finished roofing to blistering when exposed to atmospheric conditions. Data have been accumulated that indicate that at least 87 per cent of the voids in felt should be filled with a satisfactory saturating asphalt to insure against pronounced blistering of the roofing in service.

The test has the following advantages over other methods for evaluating the extent to which felt is filled with saturant:

1. Rapid—requiring less than 10 minutes for obtaining results.
2. Accurate — no correction factor needed.
3. No toxic vapors for operator to breathe.
4. Does not require special care and technique in handling samples.
5. Test may be conducted at room temperature.

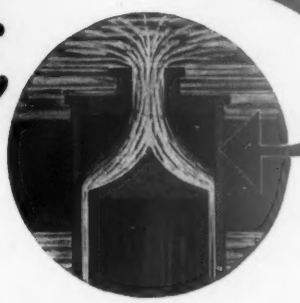
Literature Cited

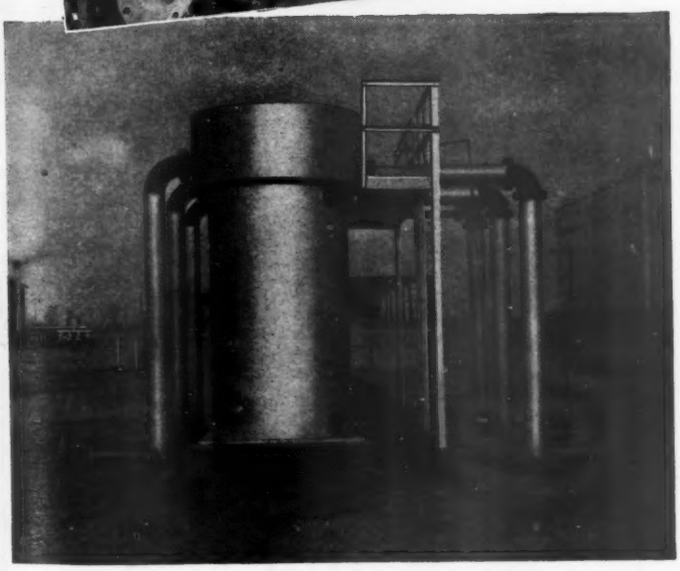
(1) Am. Soc. Testing Materials, Standards, Part III, p. 1004 (1949) (D228-48T). ★ ★ ★

Over a recent 12-month period, some 500 new petrochemicals appeared on the market, and went into the service of industry, agriculture and the home.

Dirty Water can't "Shut-down"...

Vogt





film type exchangers

(Condensers—Coolers—Evaporators)

Patent Nos. 1,935,270 - 2,057,597 - 2,424,441

River water, well water or brackish water are all alike to this exchanger *because it can be cleaned* while in operation! The water distributing ferrules need only be removed successively for the cleaning brush or tool whereby the tubes receive additional water which sluices away the dislodged dirt.

Vogt Film Type Exchangers are operating with real economy of first cost, operation and maintenance in power, petroleum, and chemical industries. They serve as Jacket Water Coolers, Feed Water Heaters, Hydrocarbon Evaporators, Sulphuric Acid Coolers, and Sulphur Dioxide Condensers, and can be designed to cool or heat any liquid and to condense or evaporate any fluid.

TOP: *Four units at Newton Falls, Ohio Municipal plant cool water for diesel engines and a lubricating oil cooler.*

BOTTOM: *Jacket Water Coolers serving engines of 7,300 HP in the compression plant of a Western Oil Refinery.*

[Bulletin HE-7 describes typical installations of Vogt Film Type exchangers and is available upon request.]

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Tops of the four treating columns holding Fuller's Earth.

Reforming Aided by Passing Charge Through Fullers Earth

W. T. ZIEGENHAIN

MANUFACTURING a base motor fuel, which after 3cc of TEL are added has an octane number well over 90, is the normal performance routine of the Bell Oil and Gas Company's refinery at Grandfield, Oklahoma. A primary factor in this accomplishment is the economical processing of the naphtha charge going to the Platforming unit. And, even though the over-all plant crude oil capacity is 7000 bbl, the great improvement in it's light product quality is accomplished with only a 5 per cent over-all liquid volume loss.

The new Platforming unit has operated continuously for about the past eight months and at the rate of 1500 bbl per day. It is producing motor fuel that has an unleaded research octane number of 82 or higher, which, with the addition of 3cc of TEL, yields a motor fuel of 92 to 94. In the starting up of the unit whenever it is necessary to bring it down, it is interesting to note that the catalyst chambers are first filled with nitrogen gas as supplied from the outside. It might also be interesting to learn that a 6 by 20 ft drum containing hydrogen under a pressure of about 600 psig is drawn upon when the unit is starting up. In operation, of course, there is excess hydrogen and virtually all of that produced is utilized in plant fuel.

Preparing Charge

The base material is produced locally as a part of the 35 deg gravity crude. That portion which serves as the major charging stock and goes to the Platforming unit, is a straight run naphtha of 460 end point. This material has a typical boiling point of 180 F. An auxiliary stream of about 100 bbl of thermally cracked 460 end point material augments the main stream. At what specific point in the assembly each stream enters, can best be seen by referring to the accompanying flow chart.

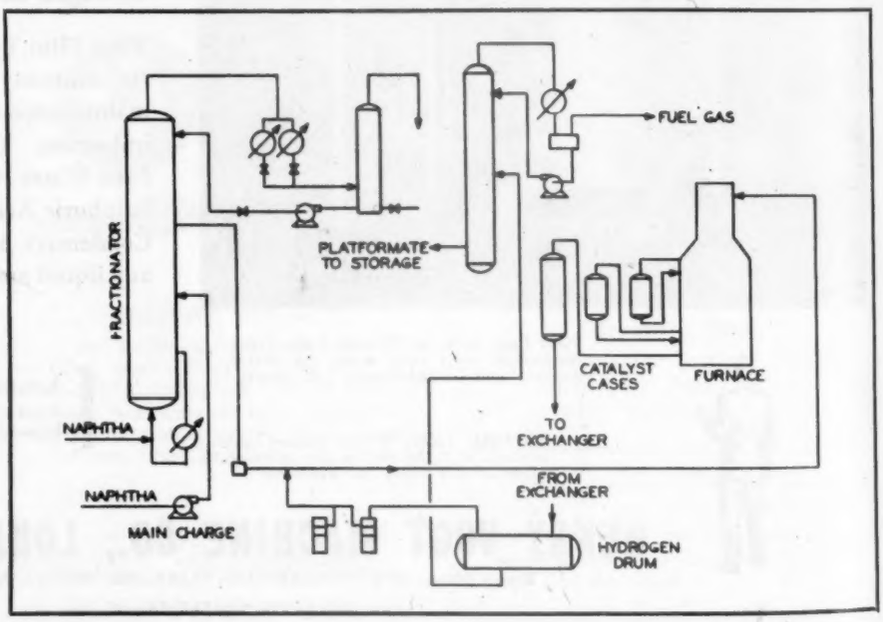
Catalyst Poisoning

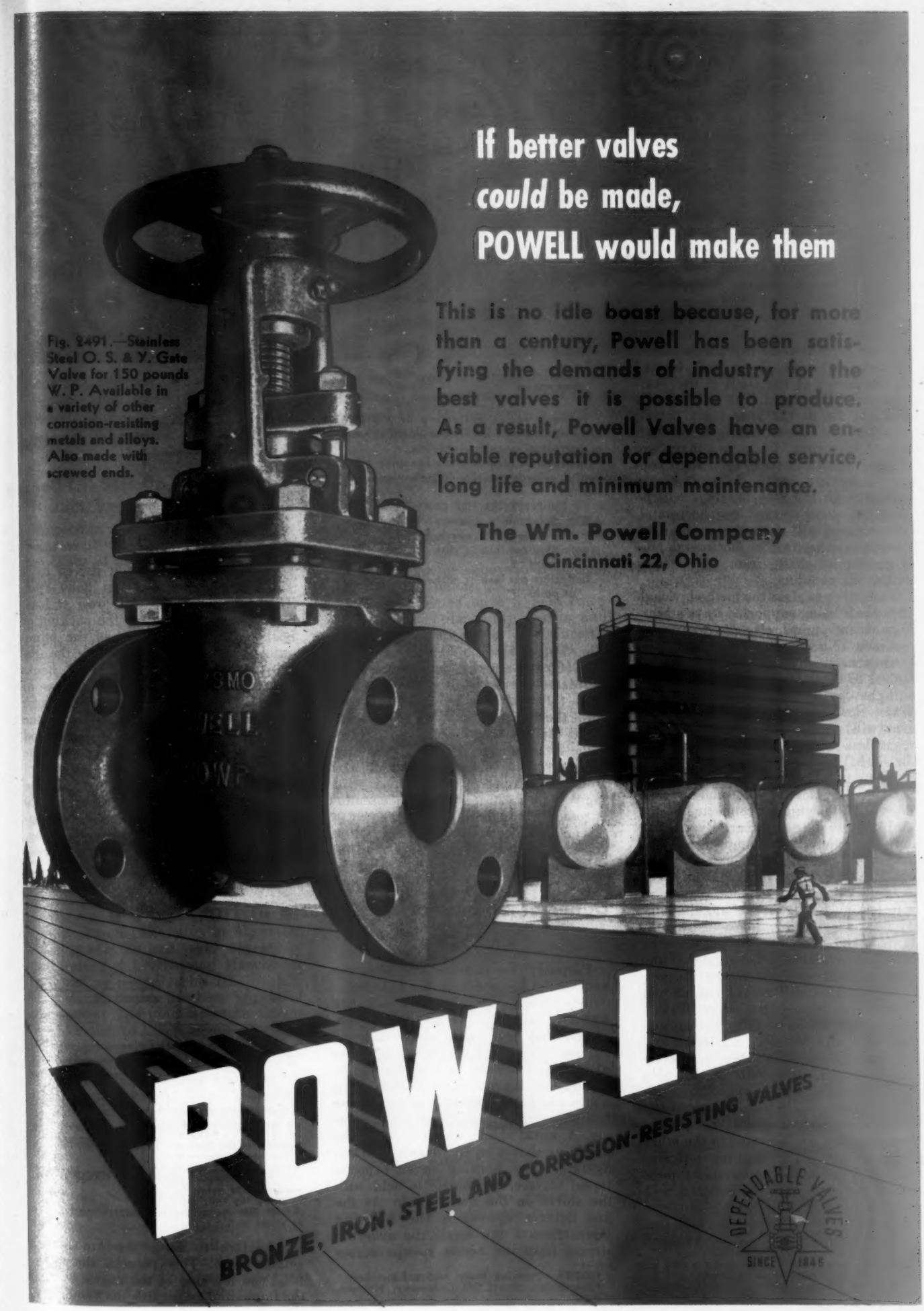
A feature of the Bell unit's operation is the economical manner in which "catalyst poisoning" was overcome. Stated in simple terms, this is accomplished by passing the charge through Fullers Earth. The units holding this Fullers Earth and through which the naphtha stream passes on its way to the Platforming assembly, comprise essentially four old treating towers.

Catalyst Life

Pictorially, these towers are here shown in part. Just how effective the adsorbing medium will remain, cannot now be stated, but it has been found practicable to expect at least 250,000 bbl of material to be recovered as product. Well over 200,000 bbl have been recovered already from this charge of earth and while a slight rise in temperature in the emitted stream is noted, there is no change in the quality or quantity of the product, processed daily.

The main flow of 1600 bbl of 460 end point naphtha enters the Platforming unit by way of the main charge pump and is charged to the prefractionator at a point approximately one third up the latter's height. Because of the balanced heat relationship and the slight reduction in pressure as this stream continuously enters the prefractionator column, its resulting vapors rise and this prefractionator operates to degasify the stream. The lighter hydrocarbons reach the uppermost portions of the tower and pass through an area so controlled with respect to temperatures that that portion of the stream composed of very light hydrocarbons passes off as a gas to the prefractionator receiver. That portion that is temporarily retained as a liquid and of course represents the greater quantity occurs as a liquid ring inside this tower and from here it is continuously withdrawn, for further processing. Off the base of this interior ring is pumped by means of a TriPlex unit, approximately 1500 bbl per day of 250 F oil to the Platformate heater and then to the first reactor. The reaction in this area is endothermic. The stream is reheated before passing into the successive reactors. Because of the change in the nature of the hydrocarbon composition of the stream, subsequent fractionation is necessary, but the volume of gases developed for removal from the system is relatively small, and these of course go to serve as fuel. * * *

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SINCE 1846

Axial Shaft Alignment*

W. H. WEAVER†

Purpose: The alignment of shafts from the rotating axis instead of from external surface.

Description: This method of shaft alignment is a departure from the usual method of using a taper gage, straight edge or single indicator. The method is not radical but the results of using it are. It aligns the shafts from the rotating axis rather than from the external surfaces. For this reason it eliminates mis-alignment caused by crooked shafts and worn or eccentric bored couplings. This method works on the principal that a shaft supported in two places, when rotated, will turn on an axis located in the center of the shaft at the bearings where supported. The rotating axis will not be in the true shaft center, except at the support points, if the shaft is bent or sprung. When two shafts are aligned by this method, each shaft supported by two bearings, the rotating axis through the four bearings will be on a line, both vertical and horizontal. This method will show the angular deflection and vertical or horizontal misalignment of shafts from the rotating axis at the coupling.

To further explain the method, visualize a shaft being supported by two bearings as are pumps, electric motors and turbines. If a clamp with an arm projecting in line with the clamp is attached to one end of the shaft, the arm will be perpendicular to the shaft. When the shaft is rotated the clamp arm will rotate on the rotating axis regardless of the amount of kink in the shaft.

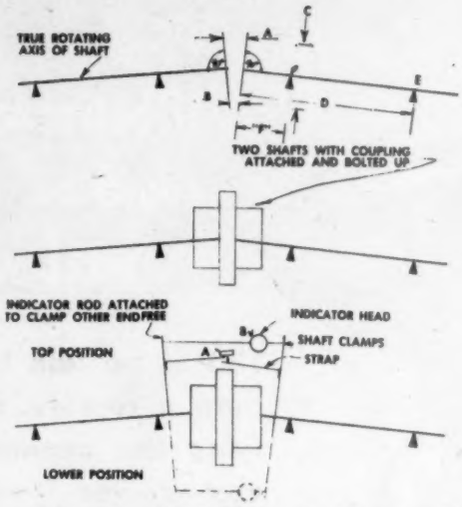
When two shafts are to be aligned, a clamp is placed on the end of each shaft and the coupling connected so the shafts will rotate together. By placing indicators on the clamp arms the amount of mis-alignment can be measured. Then definite steps can be taken to correct the mis-alignment.

Referring to Fig. 1, the angular misalignment can be measured in both the vertical and horizontal planes when an indicator is placed between the clamp arms at point (A) and rotated to position (B). This will record the amount of deflection between the shafts rotating axes in the distance (C). By turning the two shafts 360 deg. maximum and minimum distance between the arms will be found, these will be 180 deg apart. Attaching a piece of flat bar stock approximately ⅛ by 1-in. to one of the clamp arms with a small "C" clamp, then attaching an indicator to the other clamp arm, so placed that the indicator point will be in the approximate position of the shaft arm, the indicator will give the amount of deflection between the rotating axes when the indicator reading is divided by 2. By referring to Fig. 3 it will be noted that (A), (B) and (C) are equal. When the assembly is rotated the indicator will record (A) plus (C) which is twice (B). Therefore, the indicator reading must be divided by two to determine the true value of the distance (B). If one shaft is required to be 0.010-in. low or high from the other shaft the indicator reading will be 0.020 in. when the assembly is rotated through 180 deg.

This method has been used for three years. To illustrate its success, note the following example: At this plant we have one multi-pump unit driven by a 150 HP electric motor at 3580 rpm. This unit had to be shutdown at least once a month to replace the packing or bearings in one or more of the pump units. This necessitated having the distillation down approximately 4 hours each time. This resulted in a loss of about 12,000 gallons of product. These units were checked repeatedly using the straight edge and taper gage method on the couplings. They appeared to be in alignment.

When this unit was aligned by the method outlined above it operated 20 months before a shutdown. This shutdown was made to replace packing. Therefore, on this one unit the saving realized amounted to 240,000 gal.

FIG. 1.



Indicator reads deflection or A-B on top drawing. The above sketches apply to vertical or horizontal angular deflection.

Indicator A records misalignment of shaft ends, B records the angular deflection between shafts.

REFER TO TOP DRAWING

A-B = deflection in distance "C"

A-B ÷ C = deflection per inch

deflection per inch × dist. "D" = correction at point "E"

deffection per inch × dist. "F" = correction at point "P"

FIG. 2.

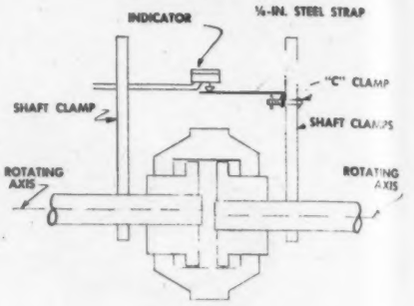
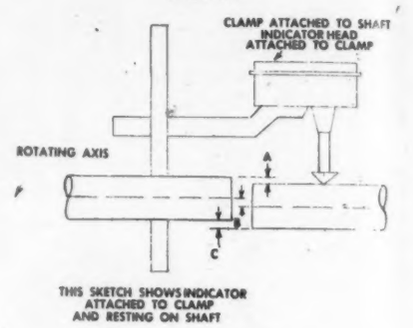


FIG. 3.

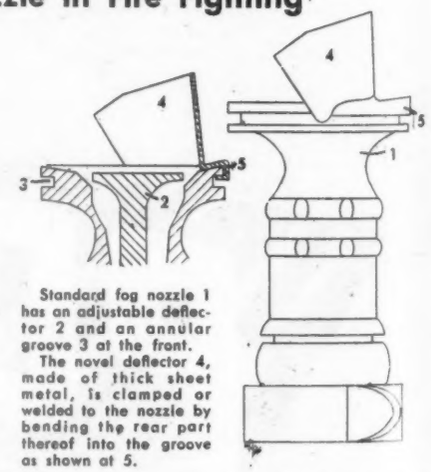

CLAMP ATTACHED TO SHAFT
INDICATOR HEAD ATTACHED TO CLAMP
ROTATING AXIS
THIS SKETCH SHOWS INDICATOR ATTACHED TO CLAMP AND RESTING ON SHAFT

Deflector Shield for Fog Nozzle in Fire Fighting†

J. F. REVIER*

Purpose: To increase the effectiveness of the fog nozzle in fire fighting.

Description: In practice oil fire fighting at this plant it was observed that fog nozzle spray directed against the oil surface caused agitation of the oil from the lower part of the stream striking the surface at a sharp angle and high velocity. Such agitation facilitates burning and hinders fire fighting. A metal shield was welded to the nozzle as shown on the drawing. When fighting a fire burning on an exposed liquid surface, the nozzle is held with the shield on the bottom side. As the fire fighters approach the burning liquid from a low angle the deflected stream from the nozzle sweeps across the surface to force the fire into a smaller area. This permits the spray from the top side of the nozzle to cool the liquid and extinguish the flame.



Standard fog nozzle 1 has an adjustable deflector 2 and an annular groove 3 at the front.

The novel deflector 4, made of thick sheet metal, is clamped or welded to the nozzle by bending the rear part thereof into the groove as shown at 5.

*Class A, first prize and grand prize at NGAA—Permian Basin regional meeting.

†Maintenance superintendent, Phillips Petroleum Company, Fullerton (Texas) plant.

†NGAA—Permian Basin regional meeting.

*Electrician, Shell Oil Company, Notrees, Texas.

Dr. C. G. Williams, manager, Product Development and Research Department.

A view from the entrance to Woodstock farm showing farm buildings and (on extreme right) the laboratory. The farm, near Settingbourne, Kent, is the agricultural research center of the Shell Group in the United Kingdom, containing a modern laboratory where chemicals are tested under controlled conditions for agricultural purposes.

Shell Oil Sets Up New Product, Research Office

A product development and research department has been set up in the London Office of the Shell Petroleum Company under the management of Dr. C. G. Williams, D.Sc. Its functions embrace both the advisory and the experimental aspects of the quality and application of products, and include the direction and co-ordination of laboratories in the United Kingdom and of that portion of the Group's research program which is carried out in this country.

The laboratories administered by the department are the Thornton Research Center, the Central Laboratories, and Woodstock Experimental Station. It has also taken over the liquid gas and kerosine activities hitherto performed by sales technical advisory department, and the technical direction of experimental work on products at the Fulham fuel oil experimental station.

Manager of the new department, Dr. C. G. Williams, joined the group in 1940 as director of research of the Aero Engine Research Laboratory at Thornton. Prior to this he had taken degrees in engineering at London and Manchester Universities, including his DS.

Dr. C. B. Davies has been appointed manager of Thornton Research Center in succession to Dr. Williams. Dr. J. E. Hardy will continue to act as manager of Woodstock Experimental Station and W. R. P. Hodgson as manager of the Central Laboratories. A. Wilson has been appointed manager of the technical division of product development and research department in London.—V.S.S.

DPA Loan to Aid Expansion

Eastern States Petroleum Company, Houston, Texas, has been given a $1,250,000 loan under the Defense Production Act. The company will use the Federal money to help finance various expansion projects. Loan must be repaid within six and one-half years.

Universal Oil Products Moves in New Home

Domiciled for the greater part of a generation at 310 South Michigan, Universal Oil Products Company moved recently into a new, modern, and "modernistic" home in suburban-to-Chicago Des Plaines, Illinois, 25 miles outside the Loop. Situated on a 54-acre tract, the three-floor plant—two stories and basement—is built of steel and concrete, employing liberally buff-tinted brick and stone as facing materials. It is 360 ft long by 75 ft wide. Windows are of aluminum frame and thermopane glass construction. With fluorescent lighting, and an air conditioning unit that circulates more than 66,000 cu ft of filtered, temperature-regulated air per minute from intakes in two roof penthouses, the installation guarantees the best working conditions the year round.

Except in the administrative offices partitions are all movable to give full opportunity to change space availability in offices, conference rooms, etc., to meet any conditions. On the first floor are the departments for personnel, purchasing, engineering, engineering research and development, service and commercial development. On the second floor, in addition to the administrative offices, are those for legal and patent departments, public relations, literature research, drafting and accounting, and the products divisions. A large part of the basement level is devoted to the cafeteria, which can serve a total of 700 persons per meal, 300 of them at the same time. This cafeteria is also specially designed and protected as a refuge in case of air raids.

This new construction is the first major step in the company's long-term policy for centralizing all its basic operations at this site. Plans call for the construction of research and development laboratories, pilot plants and auxiliary units to replace those now housed at Riverside laboratories.

Above, exterior view of new Universal Oil Products building at Des Plaines, Illinois. At right, entranceway to the building.

Natural Gas Plants Show High Capacities

Productive capacity of natural gasoline and cycle plants in the United States was 811,596 bbl of liquid petroleum products per day on January 1, 1952, according to a biennial survey of the industry presented in a Bureau of Mines information circular released by Under Secretary of the Interior Vernon D. Northrop. This represents an increase in productive capacity of 163,691 bbl per day since the last survey on January 1, 1950.

Presenting capacity data on a barrel rather than a gallon basis for the first time, the Bureau's circular shows that the industry has expanded 12 per cent per year during the 1950-52 period. This rate of expansion is only slightly below the maximum rate, recorded from 1948-50.

In spite of the enlarged production capacities, the total number of operable plants declined from 554 to 521, due to the abandonment of operations at numerous small compression plants in Pennsylvania and West Virginia. The number of absorption plants increased by 16, the Bureau reports, accounting for most of the new construction during the period.

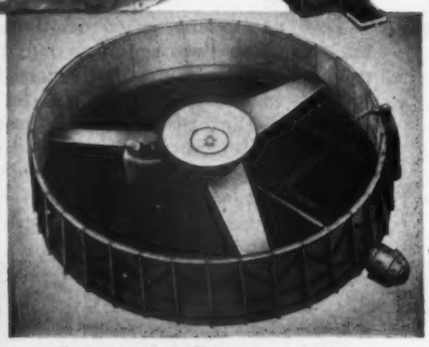
Nebraska, with one plant constructed since the last survey, has been added to the list of producing states, and New York has been dropped.

SPECIFY FOR NEW INSTALLATIONS FOR REPLACEMENTS

FANS by Moore

HOW MUCH ARE YOU PAYING FOR AIR?

UP TO 50% POWER SAVINGS



One man installation on 16' fans. No crane or crews ever necessary.

HERE'S WHY:

Assembled from standard parts with two to eight blades to exactly meet customer requirements at peak efficiencies.

HUB and blades corrosion-resistant ...Monel stainless steel or Everdur (Carbon steel for dry cooling applications).

Fool proof unitized pitch adjustment. One adjustment simultaneously sets pitch of all blades.

Diameter range for 8 to 24 feet.

Blades resiliently mounted. Air load shocks damped before reaching speed reducer.

The ONLY Fans that do ALL THIS and MORE!

BLADES:
- Uniformly balanced
- Installed at random
- Interchange between fans without destroying balance
- Corrosion-resistant metals including hub
- 5-year guarantee

FREE POWER SAVINGS SURVEY by our Engineers NO OBLIGATION

Write for "How Much Are You Paying for Air?"

WRITE TODAY

THE Moore COMPANY
MARCELINE 3, MISSOURI

API Names Refining Men To General Committees

The Division of Refining, in session the American Petroleum Institute, elected 54 refiners to serve on the General Committee of the Division of Refining for the year 1953, at the annual meeting in Chicago recently. The 54 include:

Gale S. Adams, General Petroleum; W. R. Argyle, Sinclair; M. S. Beringer, British American; Ralph Booker, National Cooperative Refinery Association; James T-B Bowles, Crown Central; George H. Burrus, Anderson-Prichard; W. J. Carthaus, Deep Rock; H. S. Chase, Tide Water; G. A. Davidson, Standard California; C. E. Davis, Shell; David E. Day, Richfield; Roy J. Diwoky, Pan-Am; J. H. Dunn, Shamrock; E. E. Ebner, Quaker State; H. W. Ferguson, Humble; Max M. Fisher, Aurora; M. Halpern, Texaco; John W. Hancock, Hancock Oil; T. A. Helling, El Dorado Refining; D. A. Hulcy, Lone Star Gas; H. Y. Hyde, Tide Water; K. E. Kingman, Union Oil California; J. A. LaFortune, Warren; J. Porter Langfitt, Pure; W. L. Lesh, Kanotex; R. E. Luton, Ohio Oil; Maurice A. Machris, Wilshire; George L. MacPherson, Imperial; F. L. Martin, Sunray; G. L. Mateer, Cities Service Research; E. B. McConnell, Standard Ohio; F. W. McCurry, Derby; L. W. Moore, Pan-Am Petroleum and Transport; William Naden, Esso Standard; Glenn E. Nielson, Husky; Harold G. Osborn, Continental; H. M. Paulsen, Bankline; Max G. Paulus, Standard Indiana; John S. Pfarr, Leonard Refineries; L. W. Robbie, Republic; J. B. Rogerson, Lion; H. H. Sherwood, Sherwood Refining; Edwin Singer, Pontiac Refining; E. F. Sondregger, Old Dutch Refining; Henry Sonneborn, III, L. Sonneborn Sons; W. F. Stroud, Atlantic; T. J. Sullivan, Gulf; C. C. Tate, Phillips; C. S. Teitsworth, Socony-Vacuum; C. H. Thayer, Sun; J. W. Vaiden, Skelly; John S. Wertz, Vickers Petroleum; L. A. Woodward, Mid-West Refineries, and W. S. Zehrung, The Pennzoil Company.

Simultaneously Frank M. Porter, Institute president, announced the appointment of 6 members of the API board of directors to the refining general committee, as follows:

Paul G. Blazer, Ashland; J. F. Lynch, La Gloria Corporation; R. E. Miller, E. I. du Pont de Nemours; A. W. Scott, Wolf's Head Refining; E. L. Shea, Ethyl Corporation, and R. L. Tollett, Cosden Petroleum Corporation.

DPA Asks for Increased Chloride and Dibromide

Sharply increased U. S. capacity for producing ethyl chloride and ethylene dibromide, used in the manufacture of high-octane aviation gasoline and other fuels has been called for by the Defense Production Administration. A goal of 630,000,000 lb of capacity to produce ethyl chloride by January 1, 1955, has been set by the DPA, an increase of 300,000,000 lb over annual production capacity at the beginning of 1951.

An increase of 90,000,000 lb in ethylene dibromide has been asked for by DPA, setting the total amount at 210,000,000 lb of annual production capacity by January 1, 1955.

These two chemicals are used chiefly in the manufacture of tetraethyl lead, used to make high-octane aviation gasoline.

W. L. Felton

F. E. Mathews

C. E. Jester

H. C. Thompson

H. C. Thompson, petroleum chemicals division, duPont Company, Wilmington, Delaware, who spoke on "How Our Business System Operates."

Employee Relations Studied

The men shown in the above photos were speakers and discussion leaders in the general symposium on employee relations, before the regional meeting of Western Petroleum Refiners Association at Casper, Wyoming, September 25-26, 1952. Left to right, are: W. L. Felton, manager, employee relations department, Phillips Petroleum Company, who spoke on "The Functions of an Employee Relations Department"; F. E. Mathews, superintendent, industrial relations division, Standard Oil Company (Indiana), Casper; chairman, industrial Relations Session; C. E. Jester, director, employee benefits division, Continental Oil Company, Houston, Texas, whose paper was entitled "Trends of Employee Benefit Plans in the Oil Industry," and

Edeleanu Building 2 Plants

Edeleanu Gesellschaft, M. B. H., Frankfurt, Germany, is engineering and constructing two new units, in Germany and in Portugal, involving the application of extractive and dewaxing solvents to refining problems. These units are:

Company	Deutsche Erdol-Aktiengesellschaft	Sociedade Anonima Concessionaria da Rafinacao de Petroleos em Portugal, Cabo Ruivo, Portugal
Location	Heide, Germany	
Project	Oil dewaxing	Kerosine, diesel, lube extraction
Capacity	210 tons per day	6600 bbl per stream day
Present status	Engineering stage	Engineering stage
Contractor	Edeleanu, staff	
Engineer-Licensor	Edeleanu	Edeleanu
Probable completion date	1953	1953

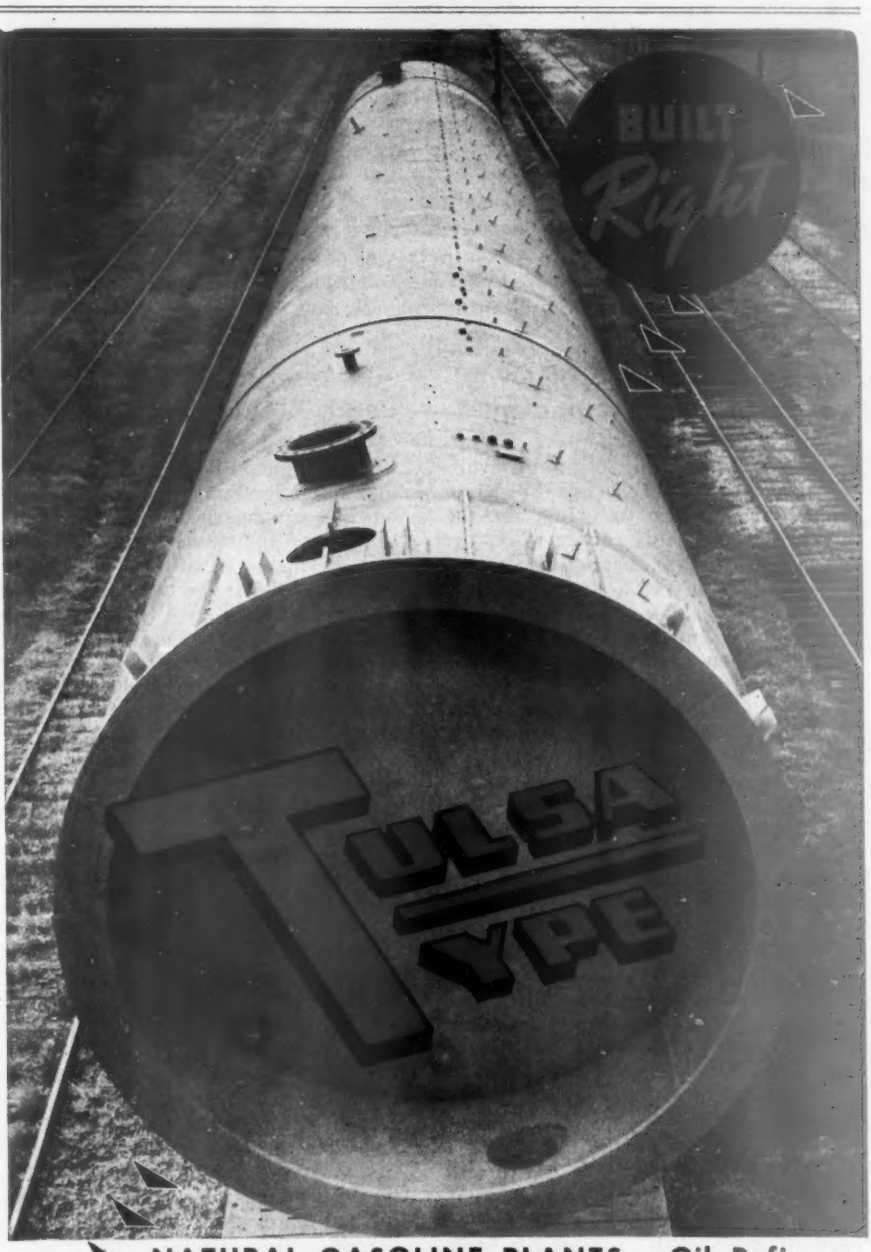
Announcement was made recently that the Edeleanu interests, pioneers in oil extraction fields, and Hydrocarbon Research, Inc., of New York, have entered into a general cooperative agreement regarding sale, design and construction of plants and units licensed under Edeleanu patents, of which more details will be published soon.

New Cutting Oils Reported

The Atlantic Refining Company announces additions and improvements in its line of non-soluble cutting oils, which it states will provide reduced friction, superior cooling, anti-weld, and metal wetting characteristics. One feature of the new oils is their transparency, from light to heavy grades, obtained from the use of a new additive.

Standard Samples of Hydrocarbons Available

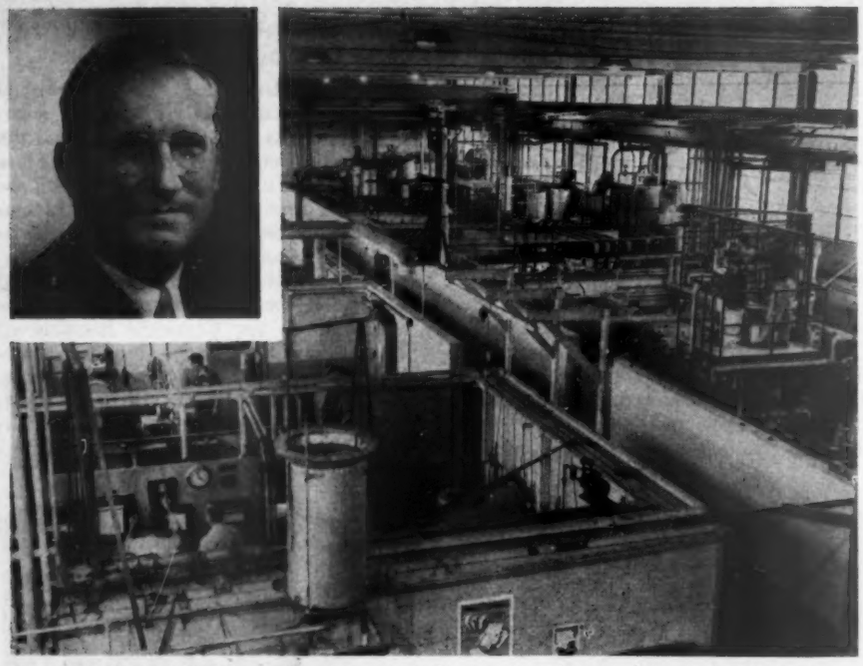
Two hundred and four compounds are available as standard samples of hydrocarbons as of July 1, 1952, from the American Petroleum Institute. Orders for samples should be addressed to Carnegie Institute of Technology, attention of Frederick D. Rossini, Department of Chemistry, Pittsburgh 13, Pennsylvania, and should be accompanied with full payment in advance, with check made out to the Carnegie Institute of Technology. Each order should give the following information for each compound wanted: Name of compound, number of the sample, size of unit, number of units, price per unit, total cost.



NATURAL GASOLINE PLANTS - Oil Refinery Equipment - Steel Plate Fabrication - Structural Steel Warehouse Steel

FLINT STEEL CORPORATION

TULSA, OKLAHOMA



General view of Houdry's Development Laboratories showing some of the many pilot plants, which furnish operational information on new and established processes. Insert is Chalmer G. Kirkbride, president of Houdry Process Corporation, who joined the company in 1947. Under his leadership, Houdry has intensified its fundamental research program in an effort to unravel the mysteries of catalysis.

Houdry Notes Date of Own Cat Cracking Development

Houdry Process Corporation is currently celebrating the 25th anniversary of Eugene J. Houdry's original developments on catalytic cracking. In the period following this earlier work, the use of catalysis has been applied to the petroleum industry, and in addition, Houdry's original concepts have been modified and extended to the development of new and vastly improved processes.

E. A. Prudhomme, Houdry's first chemist, conducted his pioneering experiments on the application of catalytic processes to petroleum hydrocarbons with apparatus that could just about fit on a kitchen table. From this beginning has emerged one of the largest independent research and development organizations in the petroleum industry. Situated on a seven-acre tract in Linwood, Pennsylvania, Houdry Process Corporation Research and Development Laboratories are equipped with the most modern facilities and staffed by some of the world's foremost catalysis men—including a number who participated in the development of the original Houdry process.

Expansion to Double Output

A $150,000 expansion program that will more than double production of road oil and asphalt products has been announced by E. M. Stone, president of Empire Petroleum Company. The refinery, situated in Denver, is the only refinery in Colorado producing various grades of road oils and asphalt products.

The expansion program will be completed early in 1953 and will raise the capacity from 2000 to 5000 bbl daily.

API Research Projects Reach "Mature" Stage

Celebration of the 25th anniversaries of two major API research projects and detailed reports on several other analogous projects marked the deliberations of the 32nd annual meeting of the American Petroleum Institute in Chicago, November 10-14. The two projects which became "of age" are Project No. 6, devoted for 25 years to the isolation, identification, and determination of properties of hydrocarbons in a typical Mid-Continent petroleum, and Project No. 37, that "led to an understanding of reservoir phenomena which ultimately saved tens of millions of barrels of high-quality distillate which might otherwise have been lost forever."

Project No. 6 was carried out at the U. S. Bureau of Standards, Washington, under the direction of Dr. F. D. Rossini, for some 23 years, and in 1950 was transferred to Carnegie Institute of Technology under the same direction. Drs. B. H. Sage and W. N. Lacey at California Institute of Technology, Pasadena, have carried on No. 37 since 1927.

These projects were begun in that year after John D. Rockefeller and Universal Oil Products Company each gave $250,000 to start non-competitive research by the Institute. Since that time the Institute has supervised the expenditure of more than $5,000,000 for research on fundamental hydrocarbon research, results of which have been given to the entire world.

Project 6 has supplied the world with more than 200 samples of pure hydrocarbons, API standards, employed widely as spectrometric standards. One hundred thirty-five individual hydrocarbons have been isolated from a single crude oil sample; 140 technical and scientific papers have been published for the information of the scientific world. In addition to the pure products a similar number of research samples of high purity are available, on loan, for the use of qualified researchers to study properties of the samples. The work of this project, confined at first to light hydrocarbons of the motor fuel boiling range, is being extended now to attack the problem of recovery, purification, and study of higher boiling fractions.

Among the seven other projects that have been prosecuted shorter lengths of time is No. 45, for the synthesis and purification, etc., of low molecular weight hydrocarbons, carried out under Dr. Cecil E. Boord of Ohio State. This project has synthesized 270 synthetic hydrocarbons, and a total of 373.6 gal, at a cost of $1325 per gallon. All these have been engine tested, along with 51 "other products." Some of these hydrocarbons, such as 2,5-dimethylfuran, cyclopentadiene, dicyclopentadiene, and pyrrolidine show "blending octane numbers" of 215 to 229! Outstanding among the results of this monumental work are new methods for synthesizing aromatics, cis- and trans-isomers of olefins, cycloparaffins such as cyclobutane and the Grignard and sodium-in-liquid ammonia reactions.

Among the papers presented are:

Synthesis, Purification and Properties of Petroleum Hydrocarbons—by S. S. Shaffer and F. D. Rossini.

Synthesis, Purification and Properties of Hydrocarbons of Low Molecular Weight—C. E. Boord and Wheeler G. Lovell.

Synthesis and Properties of High Molecular Weight Hydrocarbons—R. W. Schiessler and Harry Sutherland.

Synthesis, Properties and Identification of Sulfur Compounds in Petroleum—J. S. Ball, F. G. Bordwell, H. M. Smith, G. Waddington, and W. D. Seyfried.

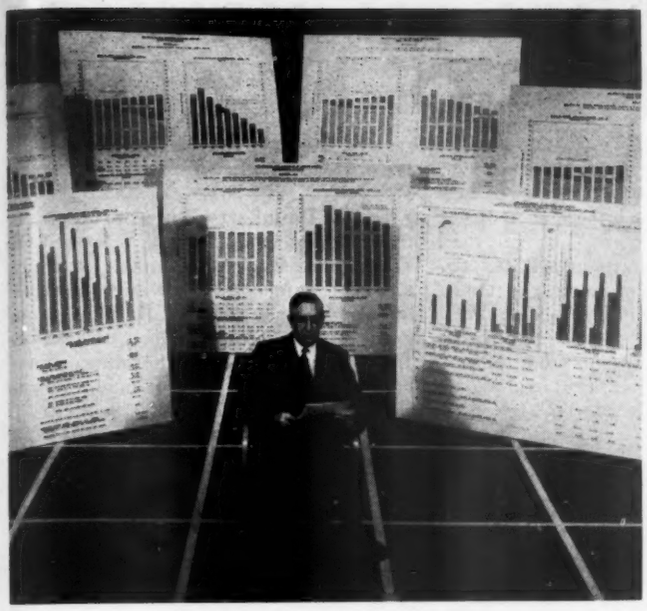
A Decade of Progress in Selecting Data on Hydrocarbons and Related Compounds—by Wayne E. Kuhn, and F. D. Rossini.

Thermodynamic Properties of Hydrocarbons and Related Compounds—R. R. Brattain.

New Sulfur Removal Process

A new catalytic desulfurization process, capable of eliminating 90 per cent of the sulfur content in sour middle distillates without appreciable product loss, is now available through The M. W. Kellogg Company, a subsidiary of Pullman Inc., as a result of a licensing arrangement concluded with Anglo-Iranian Oil Company, Ltd., it was announced by Kellogg's president, Warren L. Smith.

The process, known as Autofining, was developed by AIOC over a period of several years during which time various pilot plants were built to obtain basic operating data. In addition to a semi-commercial unit of 450-bbl-per-day capacity at its Grangemouth (Scotland) refinery, Anglo-Iranian is also operating a 3500 bbl per day plant at its Llandarcy (Wales) refinery.



What goes into the decision to invest $35,000,000? R. L. Minckler, president of General Petroleum Corporation, sits surrounded by some of the huge charts which contain the dozens of facts which had to be considered before the company's Pacific Northwest refinery at Ferndale, Washington, was decided upon. General Petroleum experts spent two years in developing the necessary facts.

First Pacific Northwest Oil Refinery Planned

General Petroleum Corporation will build the first, modern, full-scale oil refinery in the Pacific Northwest. The $35,000,000 plant will be situated on the Puget Sound near Ferndale, Washington.

The new refinery will use 35,000 bbl of crude oil per day, according to R. L. Minkler, president of General Petroleum, and will have an estimated output of 16,300 bbl of gasoline, 10,000 bbl of diesel and stove oils, and 62,000 bbl of fuel oil. The remaining 2500 bbl will become light gases that are burned as refinery fuel, or are consumed in the refinery processes.

Source of the crude oil will be Alberta, Canada, via the $86,000,000 Trans Mountain Oil Pipe Line Company that will soon be completed between Edmonton and Vancouver.

Major processing units include a crude distillation unit, Thermofor catalytic cracker, thermal cracker (vis-breaker with vacuum distillation tower), thermal reformer, and catalytic polymerizer. Storage facilities for crude oil and products will hold about 2,000,000 bbl, and completion date is estimated to be the Fall of 1954.

Shale Oil Refining Unit Planned

Catalytic Construction Company of Philadelphia, Pennsylvania, has been awarded a contract by the Bureau of Mines for process and engineering design of a new catalytic refining unit for the Oil-Shale Demonstration Plant at Rifle, Colorado, J. H. East, Jr., regional director, announced.

Boyd Guthrie, Chief of the Bureau's Oil-Shale Demonstration Branch, stated that the proposed experimental catalytic refining unit would recover better yields of specification-grade gasolines, diesel fuels, and jet fuels from the shale-oil distillates now produced in the existing thermal refining unit at Rifle.

In addition to the increased yields of gasoline and diesel fuels, which may amount to as much as 25 per cent, the anticipated advantages of the catalytic unit also include better quality products at a lower cost, Guthrie said.

The catalytic refining unit will be designed, Guthrie added, to process a variety of charge stocks, either with or without the addition of hydrogen, over a wide range of experimental conditions with the objective of developing techniques to: (1) remove the undesirable sulfur, nitrogen, and oxygen compounds that exist in shale-oil distillates or convert them to such forms that can be readily removed; and (2) effect molecular rearrangement or alteration of hydrocarbons to improve quality.

DIRECT ROUTE TO LOWER PLANT MAINTENANCE

The direct and indirect expense of replacements of short-lived refinery pipe lines can be reduced, or avoided altogether, by the use of cast iron pipe. This has been proved by many refineries whose maintenance costs have been lowered by replacing other pipe materials with cast iron. A relatively low first-cost material, cast iron pipe is usually cheapest in the end, for many refinery applications, because of its stubborn resistance to corrosion. Available with bell-and-spigot, plain end and flanged, or with standardized mechanical joints.

Cast Iron Pipe Research Association, Thomas F. Wolfe, Engineer, 1015 Peoples Gas Bldg., Chicago 3, Illinois.

CAST IRON PIPE
FOR LONG LIFE AND ECONOMY

PERSONALS

John W. Newton

▸ **John W. Newton,** who entered the oil industry 38 years ago as a chemist has been elected vice president for the refining division of the American Petroleum Institute. Named to what is considered one of the industry's top posts, Newton, Beaumont, Texas, is vice president, director and manager of refining for Magnolia Petroleum Company, an affiliate of Socony-Vacuum Oil.

Newton, who takes office immediately for a two-year term, will head the extensive refining activities of the API. A graduate in chemical engineering from Texas A and M, Newton joined Magnolia in 1914.

Appointment of the following chairmen of committees for the Division of Refining for 1953 have been announced by Newton: W. L. Stewart, Jr., Union Oil, Smoke and Fumes; John T. McCoy, Tide Water, Automotive Research; Albert E. Miller, Sinclair, Petroleum Products; C. E. Headington, Atlantic Refining, Analytical Research; R. N. Giles, Standard Indiana; W. H. Creel, Phillips; Dean S. Turner, Standard Ohio, and C. M. Ridgway, Pure Oil.

▸ **Bruce Jones** has been named refining research director for Panhandle Oil Corporation. Jones will maintain his headquarters in the Panhandle Building at Wichita Falls, Texas, and will work closely in contact with the refinery. Before joining Panhandle Oil Corporation, he was with the Girdler Corporation at Louisville, Kentucky, in the capacity of chief project engineer, fats and oil section. Before that he was employed by The Texas Company as an engineer in the refining department, both at Port Arthur and in their New York office. He is a graduate of the University of Texas.

▸ **R. O. Traylor,** assistant director of industrial relations of Standard Oil Company, has been appointed to a new position as manager of the industrial relations division in the general office manufacturing department.

E. G. Wiley and **P. T. Oak** have been appointed assistant general superintendents of Standard's Whiting, Indiana, refinery. Wiley has been superintendent of the asphalt division at Whiting. Oak has been assistant superintendent of the heavy oils division at Whiting.

Traylor joined Standard in 1922 as a clerk in the employment bureau at the Casper, Wyoming, refinery, where he became supervisor of safety. He was made assistant supervisor of labor relations at the Whiting refinery in 1942. Traylor received a master's degree in business administration at the University of Chicago.

Wiley joined the company in 1927 at Whiting. After a series of advances, he became assistant superintendent of the asphalt division in 1936. He was made superintendent of the asphalt division in 1945. He attended Bradley University.

Oak became associated with Standard in 1924 at Whiting. He advanced through positions of increasing responsibility and in 1952 was made assistant superintendent of the heavy oils division. Oak was graduated from University of Maine.

Homer Reed

▸ **Homer Reed** of Los Angeles will be president of the new Brea Chemicals, Inc., a wholly owned subsidiary of Union Oil Company of California. Formation of the company to develop, manufacture, and market chemicals from petroleum was authorized by Union's board of directors October 27. Reed, a graduate of California Institute of Technology, has been chief engineer for Union Oil.

G. H. Hemmen, manager of the Oleum refinery on San Francisco Bay for Union Oil, has been appointed chief engineer of the company. He will succeed Reed. Succeeding Hemmen at Oleum is **H. C. Meiners,** formerly assistant manager.

Harvey R. Fifer has been elected vice president of Brea Chemicals. He will have headquarters at 714 West Olympic Boulevard, Los Angeles, California.

▸ **L. V. Cassaday** has been elected president of the Lomita Gasoline Company of Long Beach, succeeding H. C. Judd. Cassaday has been vice president and general manager of the Lomita Company for many years and is widely known in Southern California. The board of directors also elected **J. E. Toussaint** chairman of the board, and **T. L. Taggart,** vice chairman.

▸ **C. H. Daugherty,** superintendent of the mechanical division of Standard Oil Company's Whiting, Indiana, refinery, has been named assistant general superintendent of the refinery. Daugherty was graduated from Marquette University in 1913 and, after other experience, joined Standard Oil Company as a foreman in the Whiting machine shop in 1916.

He became assistant master mechanic in 1921 and assistant superintendent of the mechanical division in 1928. He was promoted to superintendent of the mechanical division in 1948.

F. H. MacLaren has been appointed research associate and **L. T. Crews** has been named group leader at Standard Oil's Whiting research laboratory. MacLaren's assignment is research on wax quality and evaluation. Crews is in charge of research and development work on asphalts, petrolatums, candles.

MacLaren joined Standard in 1925 as a research chemist at Whiting and became group leader in 1941. He is a graduate of Ohio State University. Crews joined the company in 1951 as a chemist. He is an alumnus of Southern Illinois University and Oklahoma A&M College.

▸ **Louis M. Sherman** has been appointed by Ethyl Corporation to the post of associate director of product development in charge of industrial chemicals. He will serve on the staff of William T. Hack, director of product development. After six years experience in the industrial chemicals field, Sherman entered the Chemical Warfare Service of the U. S. Army in 1941. Sherman was graduated from MIT in 1938.

Robert H. Multhaup

▸ **Robert H. Multhaup** was named manager of the product engineering department of The M. W. Kellogg Company. In this capacity, Multhaup will be in charge of the design and engineering of all fabricated products.

Multhaup joined the company last year as project engineer on rocket design work. For eight years previously he was engaged in development work for the Elliott Company. His engineering degree is from the University of Iowa.

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SIZE. There is virtually no limit to the amount of heat-transfer surface obtainable in "Karbate" impervious graphite shell-and-tube-type heat exchangers. Large capacity requirements are readily met, either by a combination of standard Series 310A and 90A "Karbate" heat exchangers or with special units manufactured by the country's leading producers of heat exchange equipment.

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HYDROCHLORIC ACID ABSORBERS • STRUCTURAL CARBON • BUBBLE CAPS • BRICK • GRAPHITE ANODES • BRUSHES

Octane Ratings Show Rise in October, du Pont Says

E. I. du Pont de Nemours and Company has reported that both premium and regular grades of gasoline rose slightly in anti-knock quality from July to October. Du Pont's quarterly survey of gasoline sold in the service stations in the U. S. and Canada, revealed that the average octane rating of premium gasoline at the beginning of October was 82.2 by motor method of testing, compared with 82.1 in July and 81.9 in April.

Regular gasoline averaged 78.8 octane in October by motor method, compared with 78.8 octane in October, by motor method, compared with 78.4 in July, and 78.2 in April.

	Premium			Regular		
	Octane number		Tel content	Octane number		Tel content
	Motor October	Research October	cc/gal October	Motor October	Research October	cc/gal October
Aberdeen, South Dakota	82.2	88.9	2.43	78.3	82.7	1.74
Amarillo, Texas	80.6	88.3	2.37	77.2	80.9	2.22
Atlanta, Georgia	82.8	92.3	2.11	80.5	85.2	2.45
Bakersfield, California	84.5	89.1	2.81	76.8	81.2	1.70
Baltimore, Maryland	82.6	92.3	2.08	81.2	87.2	2.17
Boston, Massachusetts	83.2	92.7	2.31	81.3	87.5	2.15
Calgary, Alberta	77.9	87.4	2.58	75.9	81.4	2.05
Casper, Wyoming	81.1	89.7	1.71	76.6	82.2	1.47
Charlotte, North Carolina	83.0	92.3	2.27	80.4	85.3	2.40
Chicago, Illinois	82.2	90.3	2.12	78.6	83.2	1.96
Cincinnati, Ohio	82.8	91.4	2.57	80.4	86.1	2.21
Cleveland, Ohio	82.8	91.7	2.29	80.3	87.0	1.84
Columbus, Ohio	82.7	91.9	2.26	80.4	87.1	2.10
Corpus Christi, Texas	84.2	91.3	2.10	81.3	83.8	2.32
Dallas — Fort Worth, Texas	83.5	91.8	2.27	79.2	84.4	2.44
Denver, Colorado	81.2	89.1	1.83	76.8	80.7	1.81
Detroit, Michigan	83.1	91.8	2.28	80.6	86.8	2.03
Edmonton, Alberta	80.2	88.1	1.84	77.2	82.8	1.27
El Paso, Texas	78.7	86.0	2.78	74.1	76.7	1.93
Great Falls — Billings, Montana	80.4	90.0	2.30	76.4	82.6	2.15
Houston, Texas	83.8	92.0	2.27	79.6	84.9	2.52
Indianapolis, Indiana	82.2	90.2	2.17	78.7	83.8	2.04
Jacksonville, Florida	82.4	92.2	2.12	80.3	86.0	2.21
Kansas City, Missouri	82.3	90.1	2.34	78.8	83.0	1.87
Little Rock, Arkansas	83.0	91.4	2.13	79.1	84.1	1.64
Los Angeles, California	81.9	90.6	2.34	77.1	82.3	1.70
Louisville, Kentucky	82.5	91.3	2.46	79.9	85.2	2.47
Memphis, Tennessee	82.8	91.5	2.32	79.6	85.1	2.16
Milwaukee, Wisconsin	82.6	90.7	2.10	78.5	83.6	1.92
Minneapolis, Minnesota	82.5	89.5	2.46	78.9	82.6	2.06
Montreal, Quebec	81.8	90.4	1.59	80.4	85.5	1.35
Nashville, Tennessee	82.9	91.6	2.38	79.4	85.2	2.30
New Orleans, Louisiana	83.7	91.7	2.58	79.3	84.8	2.23
New York, N. Y. (Metropolitan Area)	83.6	92.6	2.28	81.1	87.0	2.13
Omaha, Nebraska	82.7	89.5	2.38	78.7	83.0	1.73
Philadelphia, Pennsylvania	81.9	92.3	2.10	80.5	87.1	2.10
Pittsburgh, Pennsylvania	82.2	92.5	2.29	80.4	86.8	2.12
St. Louis, Missouri	81.6	90.2	2.02	78.3	82.7	2.03
Salt Lake City, Utah	81.3	88.3	1.55	76.0	80.1	1.05
San Francisco, California	82.2	91.1	2.35	76.5	82.0	1.15
Seattle, Washington	82.4	90.9	2.37	77.2	82.3	1.79
Shreveport, Louisiana	84.2	91.0	2.75	80.1	84.9	2.24
Spokane, Washington	81.5	89.9	2.22	77.1	81.9	1.90
Toronto, Ontario	81.4	90.4	1.82	79.2	85.9	1.45
Tulsa, Oklahoma	83.1	89.8	2.42	79.5	82.6	2.25
Vancouver, British Columbia	81.8	88.9	2.68	79.2	83.6	1.82
Wichita, Kansas	82.9	89.1	2.43	78.5	81.8	1.68
Winnipeg, Manitoba	81.2	88.8	1.88	78.6	84.7	1.21

Humble Plans World's Largest Deasphalting Unit

Humble Oil and Refining Company has announced plans to build a unique solvent deasphalting plant at Humble's Baytown, Texas, refinery. Said to have twice the capacity of any deasphalter heretofore designed, the plant will charge 28,000 bbl per day of vacuum reduced crude, providing additional clean feed stock for two recently enlarged Fluid catalytic crackers at Baytown. Erection of the deasphalter will begin as early in 1953 as materials procurement will permit. Warren L. Smith, president, M. W. Kellogg Company, has announced that his company has been awarded the contract for design and construction of the plant.

Cat Cracker in Operation

Standard Oil Company of Texas recently put into operation a new 11,500-bbl per day Houdriflow catalytic cracking unit at its El Paso, Texas, refinery. This Houdriflow installation constitutes part of the present expansion program with modern facilities announced earlier by the Standard Oil of Texas. The new unit, begun last October, 1951, has been engineered and constructed by Catalytic Construction Company of Philadelphia, Pennsylvania.

Shell Sulfur Recovery Unit Is Put Into Operation

A unit that will recover up to 55 tons of elemental sulfur daily from waste refinery gases recently went into operation at the Houston plant of the Shell Chemical Corporation. The new sulfur recovery unit, certified by the government as a necessary defense project, was constructed by the Ralph M. Parsons Company of Los Angeles.

More than 40 plants for recovery of sulfur from hydrogen sulfide are either planned, under construction, or in operation in the U. S. today.

An unusual feature of the unit is that the sulfur will be stored in molten form in an underground tank at a temperature of 300 F. It will remain in this state throughout loading and transporting in specially insulated railroad tank cars.

PLANT AID

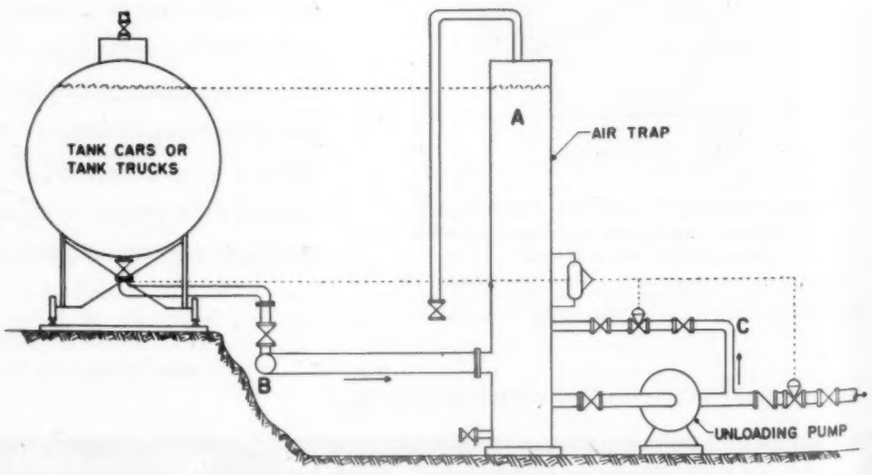
Liquid Unloading Apparatus[5]

A. L. HICKERSON*

A vessel or air trap, "A" connected to a header "B", which in turn is connected to the outlet connection of a number of tank cars or tank truck compartment outlets. The hydrocarbon being unloaded thus flows by gravity from header "B" into vessel "A". The unloading pump is connected into the bottom of vessel "A", discharging through a check valve, motor valve and block valve into storage. A by-pass line "C" discharges back into vessel "A" from the pump disharge line. A level control on vessel "A" controls both the by-pass MV and the pump discharge MV. When the level is high, the by-pass MV is closed and the discharge MV is open. When one tank car or compartment becomes empty, the level control automatically starts opening the by-pass MV and closing the discharge MV, until all cars or compartments are empty, then the by-pass MV is wide open and the discharge MV is completely closed. Thus, this apparatus allows the completion of the unloading operation without "gassing off" the pump. * * *

[5]Class B, first prize, NGAA — Panhandle-Plains Regional Meeting, Amarillo, Tuesday, November 20, 1951.

*Phillips Petroleum Company, district engineer, gasoline department, Phillips, Texas.



Apparatus, including air trap, for unloading liquid from tank cars or trucks.

Lining up pipe preparatory to running the stringer bead.

P 615.

Newest Oil Pipe Line In Full Operation

Wyoming-to-Illinois 1056-mile system provides Rocky Mountain area with much needed outlet and gives lift to oil industry

CRUDE oil is now moving through the nation's newest transportation facility.

Full operation of the 1056-mile large diameter Platte pipe line was announced on December 1 by Millard K. Neptune, president of Platte Pipe Line Company.

The new line, a 100,000-bbl-per-day common carrier, stretches from the Big Horn Basin of northern Wyoming across Nebraska, northeastern Kansas and Missouri, and terminates at Wood River, Illinois. The Wood River area is one of the nation's largest inland refining centers, as well as the junction point with other pipe lines transporting oil to refineries to the East and to the North.

The Platte story has many parallels with the old-time drilling for salt. Sometimes oil was found with the salt, but it could not be marketed and had little value. The Rocky Mountain oil producer was in a similar fix before the completion of the Platte pipe line, for frequently he had oil he could not sell. In fact the Rocky Mountain oil producer was worse off than the salt prospector, for he didn't even have salt to sell.

The states of the Rocky Mountains have not been generally regarded as important oil producing states even though crude oil production in Wyoming is exceeded only by that of the states of Texas, California, Louisiana, Oklahoma, and Kansas. The petroleum industry is not, however, a new industry to the Rocky Mountain region. The world's second oil field was discovered near Canon City, Colorado, in 1862, and oil was produced in Wyoming as early as 1883. At the turn of the century, the Rocky Mountain crude oil production averaged only 1000 bbl a day. Geologists recognized the Rocky Mountain region as a promising petroleum province, and over the years many important oil fields have been found in the area.

As the use of the automobile ex-

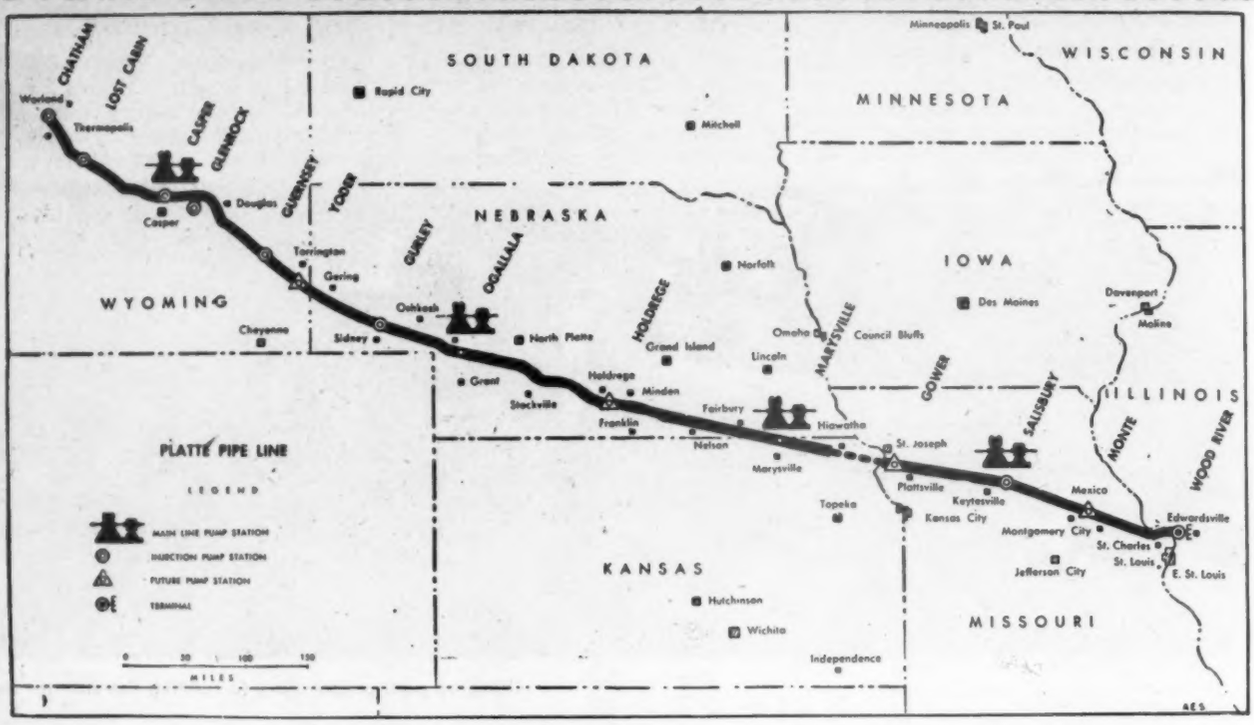
Millard K. Neptune
President

Ralph F. Moore
Vice President

Frank R. Havens
Treasurer

Dale Heltzel
Attorney

K. G. Houghlan
Assistant to President



panded during the first part of the century, crude oil production in the Rocky Mountain area expanded to supply the local demands. These Rocky Mountain petroleum reserves, however, were too far distant from the St. Louis and Chicago refining and consuming areas to be marketed. Local requirements expanded greatly with the increased development and mechanization of the area. Although a single pipe line serving the area had a capacity of 50,000 bbl a day, there was still an excess of crude oil in the area.

Substantial portions of this unused productive capacity was attributable to wells and fields owned by The Ohio Oil Company, Sinclair Oil and Gas Company, The Pure Oil Company, British-American Oil Producing Company, and Continental Oil Company. It was these five companies that, demonstrating confidence in the Rocky Mountain areas as an oil producing region and also demonstrating confidence in their own abilities to find and produce oil, joined together to organize the Platte Pipe Line Company. Thus was projected the construction of the first major pipe line motivated wholly for the purpose of transporting crude oil to a market, rather than for the purpose of providing a source of crude oil for a refinery.

Although the decision to go forward with the Platte pipe line project had been made prior to the outbreak of hostilities in Korea, the United States had reverted to national emergency status before the line pipe could be delivered. The stop-gap priorities system adopted by the government had the effect of directing substantial quantities of steel into military activities but made no provision for weighing the merits of civilian uses competing for the balance of the steel.

As a consequence, steel directed into military channels was deducted not from the refrigerator and car manufacturers who had stabilized steel requirements, but from the industrial expansion projects, such as the Platte pipe line, which had only one-time steel requirements.

When the Controlled Materials Plan was eventually imposed, Platte was certified as essential to national defense. By this time, however, steel supply was extremely tight, and the line pipe that had been originally scheduled for delivery to Platte during the first two quarters of 1951 was re-scheduled for delivery over a period extending into July, 1952. The steel strike in the summer of 1952 resulted in further delays, and the last pipe was finally received on October 17, 1952. Construction work had been scheduled so closely behind pipe deliveries that at times the pipe was being taken directly from the stringing trucks into the laying operation.

Contrary to the cases of tanks and line pipe, no serious difficulties were encountered in the deliveries of motors, pumps, valves and fittings, switchgear, buildings, and other items for the stations. Consequently, when the final weld was made on the pipe line, everything else was ready to begin operations.

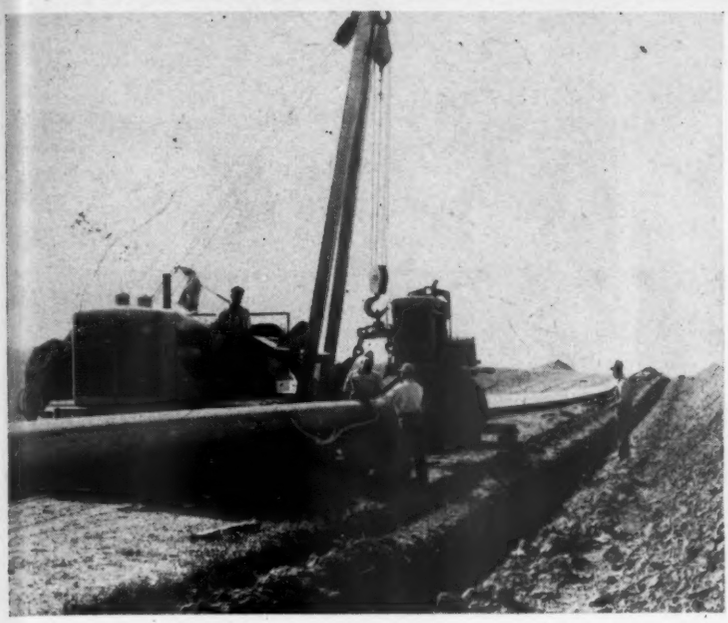
Present plans call for Platte Pipe Line Company to handle three separate grades of oil by batching operations. One stream will be low gravity sour crude produced mainly in the Big Horn and Wind River basins. The sweet crude stream will originate principally in the fields of eastern Wyoming and the Denver-Julesburg basin of Colorado and Nebraska. In addition, a third stream will be provided for those crudes that have a sulfur content above the maximum permitted in the sweet stream but which are free of hydrogen sulfide.

The Platte Pipe Line Company will act as a common carrier. At Salisbury, Missouri, and Wood River, Illinois, it connects with other pipe lines, which can carry the oil to the principal refining centers in the Great Lakes area and farther east. The bulk of the shipments over Platte will be destined to Wood River, Chicago, Bayshore (Toledo), and Earhart (Detroit), but there also will be shipments destined as far east as Olean, New York, and Falling Rock, West Virginia.

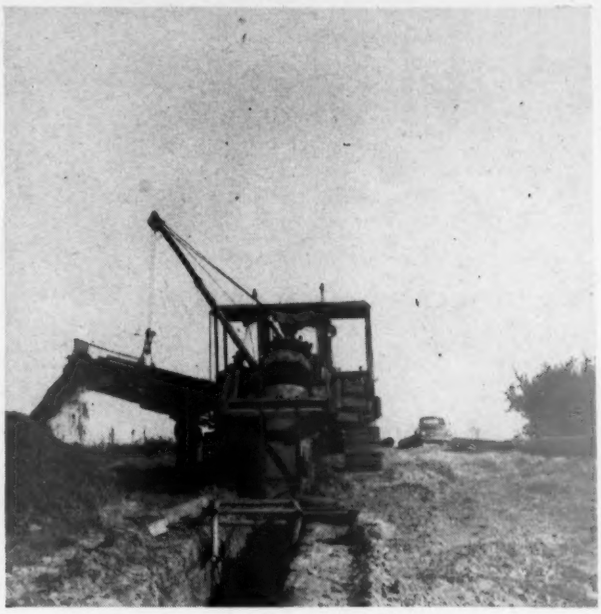
Although the Platte pipe line will have the greatest significance to the petroleum industry of the Rocky Mountains, it will also have a noticeable impact upon the general commercial activity of the region. Much of the income will be reinvested in further exploration and development activities, which, in turn will create more production and more revenue to be spent in still more exploration and development.

That these predictions are not fanciful is shown by the fact that the initial announcement of the proposal to build a pipe line brought about increased activity. In 1951, the first full year after the Platte pipe line project was announced, the number of active seismic crews in the Rocky Mountains increased 52 per cent over the previous year. Drilling rigs in operation increased 60 per cent, and wells completed in 1951 exceeded the wells completed in 1950 by 33 per cent. While wells completed in the Rocky Mountains were increasing 33 per cent, the increase for the entire United States was less than 3 per cent.

The tariffs, which have already been announced, have demonstrated Platte's intention to provide low cost, common carrier transportation for those who desire to purchase in the Rocky Mountains for use at Wood River and points east. The low tariffs provided by Platte are possible as a result of modern design and construction of the system. The economics thus made possible are being passed on to the shippers, and, as a consequence, the Rocky Mountain region is no longer a petroleum province being held as a reserve for the future, but is an important contributor to the nation's crude oil requirements. ★ ★ ★



Cleaning and priming pipe in Kansas.



Trench was cut to provide 18-in. cover in Wyoming and 24-in. elsewhere.

P 615.

DESIGN AND CONSTRUCTION

Details of pre-construction preparations and problems involved in actual laying of line

MELVIN M. LEE

SEVERAL years ago, the necessity for an outlet for the vast reserves of crude oil in Wyoming was insistently being impressed upon local producers and the oil industry.

Farsighted engineers were exploring avenues for delivering oil to the refineries where it was needed. They were fired with the desire to create a much needed artery from the earth's supply to meet the demands of a world that would continue its swift growth of mechanization as it recovered from the ravages of war. It became a goal to have the plans ready for a big inch pipe line by the time steel was available.

The culmination of those dreams are being realized with the completion of the Platte Pipe Line. The sour crude oils from the Big Horn Basin can now be pumped from Chatham station, near Worland, Wyoming, through a 16-in. line that snakes it ways up through the rugged terrain of the Big Horn Mountains and then, finding a gap at an elevation of 6300 ft, crosses the mountains and drops a thousand feet to the mile-above-sea-level Casper pump station. Here this oil becomes part of the tenders of sweet and sour crude oil from the Wind River, Powder River, and Great Divide Basins to make up the 50,000 bbl per day stream that will flow through the 20-in. line that traverses eastern Wyoming.

In western Nebraska, where the line goes through the Denver-Julesburg Basin, an additional 25,000 bbl per day will be added to the stream from the newly discovered fields of that area.

The Author

Melvin M. Lee is design engineer for Platte Pipe Line Company. He was associated with the Sinclair Pipe Line Company during its infancy in products pipelining and took an active part in the design and construction of pump stations. He was transferred to the Platte engineering department in 1951 to assist in pipe line and station design. Prior to his work with Sinclair he was employed by the Phillips Petroleum Company in the land and geological department.

From there, the line traverses the southern part of Nebraska, the northeast corner of Kansas, and continues through central Missouri, crossing the Mississippi River at a point north of St. Louis to terminate in Illinois at the Wood River refineries, where the elevation is about 430 ft.

The location of this line was chosen after reconnaissance of various routes by low flying planes and motor safaris. The Aero Exploration Company contracted to provide aerial photographs to aid the land men in procuring rights-of-way and to aid the engineers in making a preliminary survey. The Universal Mapping Company supplied the personnel to work under Platte supervision making the preliminary and final surveys and preparing the special maps required for crossing public lands. The rest of the preliminary mapping was done entirely by Platte personnel. Strip maps were drawn to a scale of 1 in. to 1000 ft.

A hydraulic gradient chart was made from existing Geological Survey maps correlated with field barometric readings. On the basis of hydraulic studies made from the chart, it was determined that eight pumping stations would be needed for flexibility in pumping from 70,000 to 150,000 bbl of oil a day. Four

Stringing pipe along the right-of-way.

Closeup of welder making a filler bead.

Ditching machine has moved across a gully and backhoe is making pipe line trench.

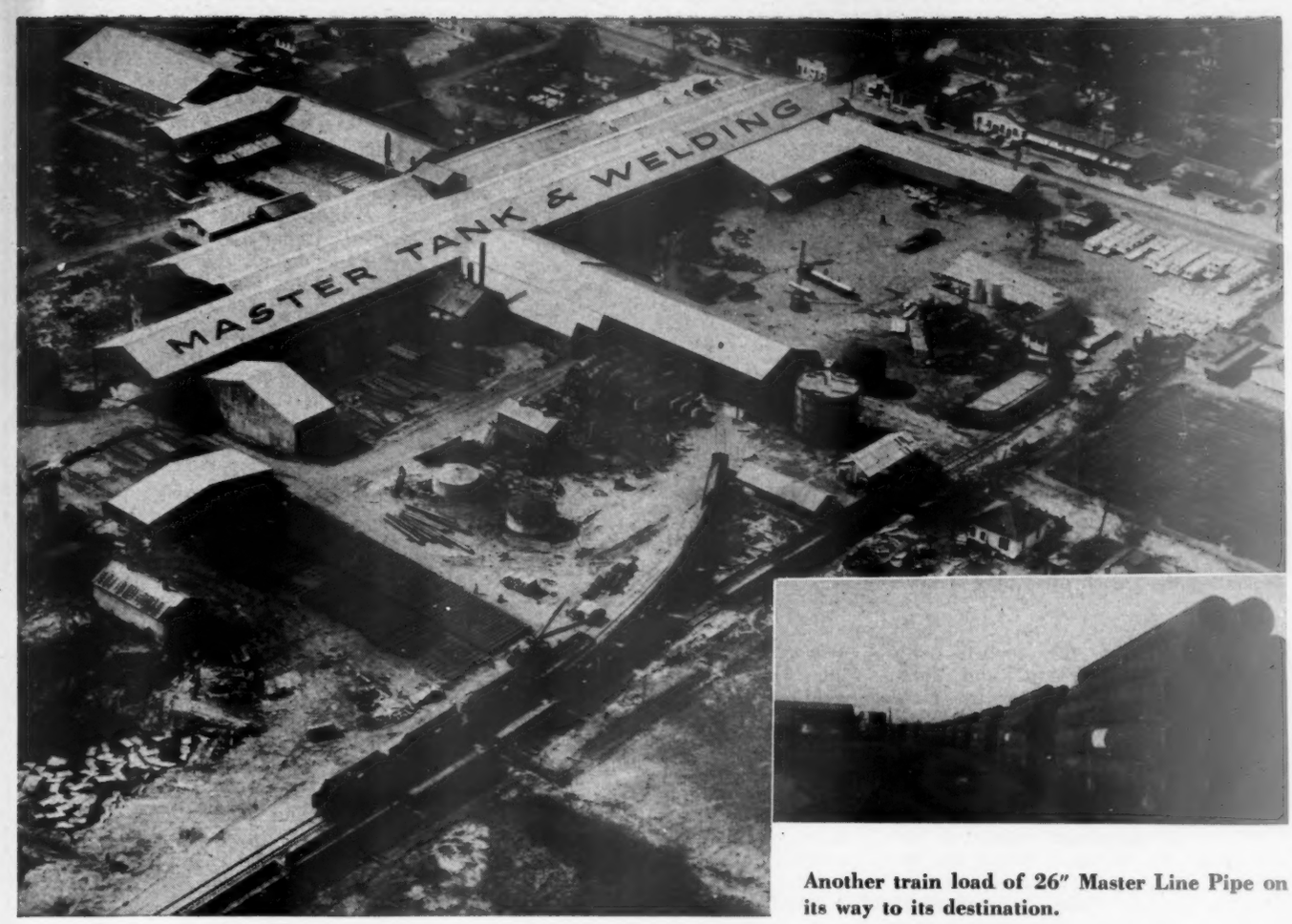
Below, bending a joint of pipe on a Nebraska spread.

of these stations were set up for immediate construction, and the other four are to be built as the additional capacity becomes needed.

Relatively little trouble was encountered in the acquisition of rights-of-way. Every effort was made not to exercise the right of eminent domain. On only 24 of the more than 3000 properties was it necessary to resort to condemnation procedures and several of these were occasioned by the legal incapacities of owners to execute right-of-way agreements.

In the early part of 1951, with a promise of a good schedule for the rolling of steel, plans and specifications were supplied to 34 pipe line construction companies requesting that they submit bids for installing any one or more of the eight sections into which the 1056 miles of line had been divided for contracting purposes. In considering these bids, serious emphasis was given to past performance records and the number of spreads that the prospective contractors could mobilize to accomplish the earliest completion possible with the anticipated pipe delivery schedules. R. H. Fulton and Company of Lubbock, Texas, was the low bidder on the first four sections comprising the western half of the line. Bishop and Lock Construction Company of Dallas received the contract for laying section 5 from Holdrege, Nebraska, to Marysville, Kansas; however, they later assigned this contract to Fulton and Brodie, Contractors, of Lubbock. Section 6, being about 100 miles across the northeast corner of Kansas, was awarded to Rumsey Brothers Pipe Line Construction Company of Wichita, Kansas, and the O. R. Burden Construction Corporation of Tulsa, Oklahoma, was awarded the contract for Sections 7 and 8 stretching across the entire state of Missouri from the Missouri River, south of St. Joseph, to the Mississippi River, north of St. Louis.

The inspectors' daily reports portray the construction problems peculiar to each state. In Wyoming, it was the inevitable winds and irrigation ditches



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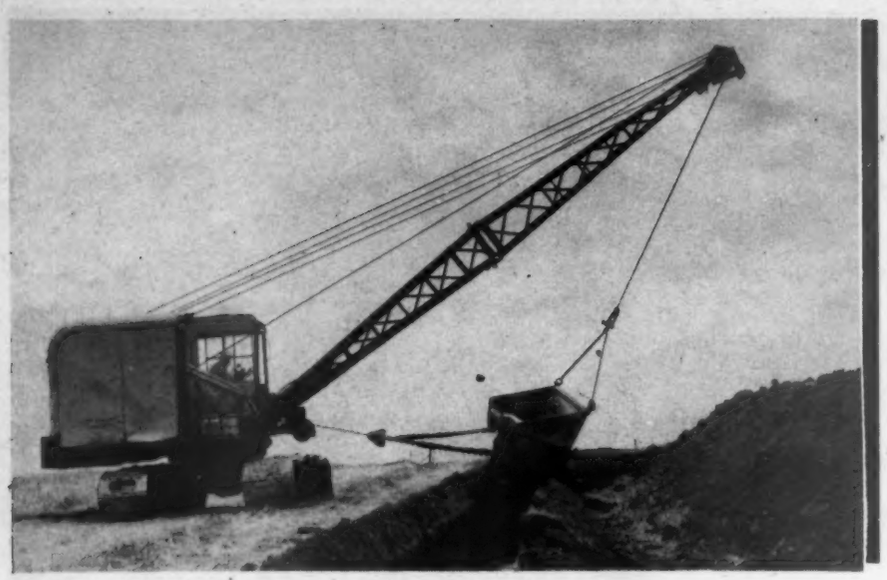


Backfilling the trench after pipe is lowered in.

that characterized the reports with "blowed out at 10:00 a.m." and "span 10 ft wide 4 ft deep." Through Wyoming and a large part of Nebraska the right of way inspector never had occasion to sharpen his pencil to report "clearing timber." Contrary to a general impression of Kansas as being a dry state, in the northeast corner of the state near the Missouri River, the inspectors' daily reports attest to "tractors mired in gumbo." Crossing the State of Missouri offered most the problems that can beset a "big incher." In Missouri can be found rock that requires technical advice for blasting, ditches that stay full of water, cold that makes it necessary to heat the pipe before welding and a heat that won't let the dope set on the pipe.

Platte used a Class X-52 pipe, and the specifications called for the pipe to be welded by the electric shielded arc process using A. W. S. Class E-6010 electrodes (Lincoln Fleetweld No. 5) for the stringer (5/32 in.) and cap (3/16 in.) beads; with A. W. S. Class E-7010 electrodes (Lincoln Fleetweld No. 85) for filler (3/16 in.) beads.

The Elder and McNulty Company of Tulsa, Oklahoma, has X-rayed 10 per cent or more of the welds on the main line. All welds to be inside casing, and welds made for river crossings were 100 per cent X-rayed and given the soap test with 100-psi air pressure. X-rays did disclose some bad welds but also revealed that the welding specifications were satisfactory. In the entire job the X-ray was not used as a club over the welders but a tool to accomplish better welding results.

Applied to the pipe line was composite coat consisting of a primer, a 3/32-in. minimum thickness of coal tar enamel, a wrap of glass fiber matting pulled completely into the hot enamel, and a final wrapper of Kraft paper over the enamel.

Except where special requirements existed, the minimum cover was maintained at 24 in. in all states other than Wyoming, where a minimum of 18 in. was maintained. Through rocky areas and under roadways that were ditched and not cased, the pipe was wrapped with a 3/16-in rock shield.

The original plans called for Platte Pipe Line to begin operations in November, 1951, but the Korean situation and the steel strike repeatedly delayed the delivery of pipe. The intention to use eight spreads never materialized. Four was the most that were in operation at one time.

Pipe delivery to the west end of the line was such that Fulton was able to keep only one spread in operation for the full length of the contract. This broke all previous records for continuous length of "big inch" laid by one spread. Under the supervision of the same personnel, this spread laid 126 miles of 16-in. pipe and 423 miles of 20-in. pipe for a total of 549 miles with one spread with a consistently high daily average. With the delays in pipe delivery, the cost of construction rose sharply. Contracts had to be renegotiated with premium rates, this being the price of continuing progress during the winter months.

Two major rivers were crossed with this line. Separate contracts were let for the Missouri and Mississippi river crossings. The Missouri was crossed at a point a few miles south of St. Joseph where the river is about 1200 ft wide. The Missouri Valley Dredging Company of Omaha, Nebraska, undertook this crossing and was successful in laying the line on the river bed and sucking a trench for it to fall into. Specifications called for a minimum cover of 10 ft to be maintained in the channel, and this necessitated an excavation of 35 ft in depth on one bank. Pipe with a wall thickness of ½ in. was used for this crossing. A flood coat of coal tar was added to the regular covering before a 2½-in. thickness of concrete was Gunited over steel mesh for weight.

The Mississippi was crossed a few miles north of St. Louis where it measures about 2000 ft from waters edge to waters edge. O. R. Burden effected this crossing by dredging and lowering the pipe into the trench from barges. Also, a spare or stand-by 12-in. line was laid tieing to the main 20-in. line on either side of the river. Both of these lines were ½-in. wall pipe with the same coating and weighting as used on the Missouri River crossing. The 20-in. line was laid in a straight line whereas the 12-in. was arched upstream.

In the smaller streams and swamps, concrete weight clamps were used.

As a step in the cathodic protection of the line, test points were installed as the line was constructed. Rectifiers will be installed as the tests indicate their need. Numbered aerial markers have been placed at three mile intervals to assist the patrol pilots in their periodic inspections of the line.

As sections of the line were completed, they were water tested at 1000 psi for 24-hr periods and then filled with oil. Stocks for filling the line were arranged several months in advance. Due to the location of the stocks accumulated, some sections of the line were filled from the east to the west and other sections were filled in the intended direction of flow. No difficulty was encountered in filling the line.

The water testing of the line has revealed only two small leaks, both of which were in the mill seams of the pipe.

* * *

A minimum of 10 per cent of the welds were X-rayed on the main line.

Chatham—the first station on the system.

Injection station at Lost Cabin, Wyoming

P 615.

PUMP STATIONS—Heart of the System

Economical construction, operation, and maintenance was the primary aim in designing the motor-driven centrifugal stations

FRED MARTS

In the design and construction of the Platte Pipe Line pump stations the principal aim was to accomplish economical construction, operation, and maintenance. A secondary aim was to attain neat appearance, and in all this, it was borne in mind that the stations would be adapted to automatic operations.

On each station site, there was erected a separate pump building and a control building. The pump buildings are all similar in construction details, each having prefabricated structural steel framework with corrugated transite siding and roof, with the Transitop interior finish. A traveling crane for use in pump and motor repair was installed as part of the building equipment. An individual gage panel was provided for each pump. Each panel contains suction and discharge pressure gages, suction and discharge pressure transmitters, and five mercoid control switches connected to each pump and motor combination. Three of the mercoids are for temperature units and were installed on the inboard and outboard motor bearings and pump casing. Low suction and high discharge pressure mercoids were installed in the suction and discharge for each pumping unit.

Brick cavity wall construction has been incorporated into the control building superstructure, whereas the interior is finished with glazed tile walls, acoustical tile ceilings and concrete slab floors over-laid with grease-proof asphalt tile. Each building is divided into a control room, a gager's office, a laboratory, a workshop and storage room, a boiler room, and a toilet. Office areas have the advantage of fluorescent lighting. Explosion-proof fittings and fixtures have been used in the laboratory.

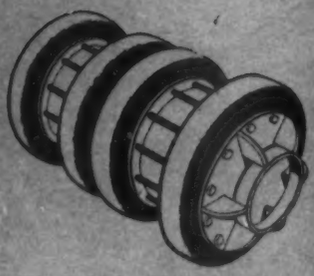
The outstanding feature of the building is the flow control panel. This panel, which is of steel construction with a black formica front, covers almost one entire wall of the control room and has full length doors opening from the workshop which allow access to the wiring and piping of the instruments and controls. The panel provides a visual picture of the valves and piping of the entire station with red and green lights indicating the open and closed positions of each valve. Gages mounted on the panel indicate the tank manifold pressure, suction pressure, and the discharge pressure for each pump and for the discharge line. An electronic tank gage transmits to this panel an instant reading of the stocks in any tank at the particular station. The panel also makes possible push-button control of all pump motors and motor-operated valves. Suction and discharge pressure recorder-controllers and a flowmeter recorder are also included on the panel. All instruments in the panel are either electrically operated or air operated. No crude oil is in any way piped into the control building.

The Author

Frederick Marts, senior engineer of Platte Pipe Line Company, was born November 20, 1925, and reared in Kansas City, Kansas. He was graduated from Wyandotte High School in 1943, and served in the U. S. Army Air Force from 1943 to 1945. Attended Finlay Engineering College of Kansas City, Missouri, receiving BS degree in civil engineering in 1949. Was active in pipe line construction while associated with Panhandle Eastern Pipe Line Company before joining Platte in 1951. He is a member of Missouri and National Society of Professional Engineers.

...for dependable Big-Inch pipeline cleaning—

follow the leaders

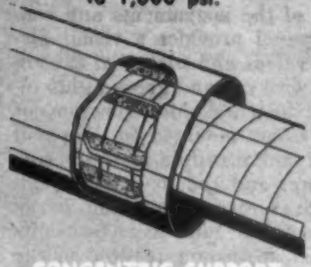


LB-4 PIPELINE PIGS

For initial filling with liquid . . . to displace air from over-bends. Also to separate hydrostatic-test water from the initial batch of oil.

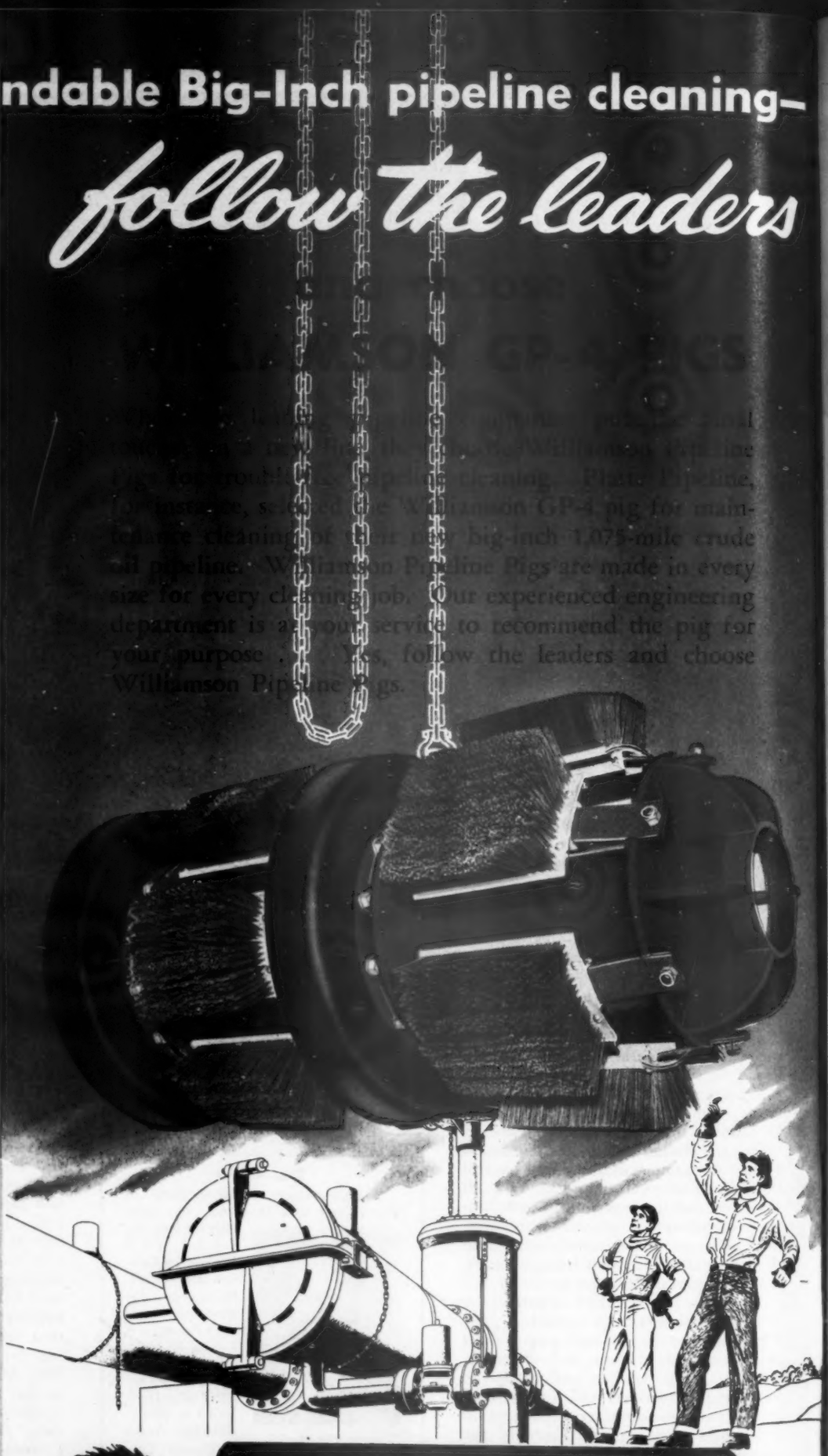
HILLCO TAPPING MACHINES

For making 12" or smaller lateral connections to the pipeline . . . without shutdown . . . against line pressures up to 1,000 psi.



CONCENTRIC SUPPORT INSULATORS

For use where pipelines pass through right-of-way casings.

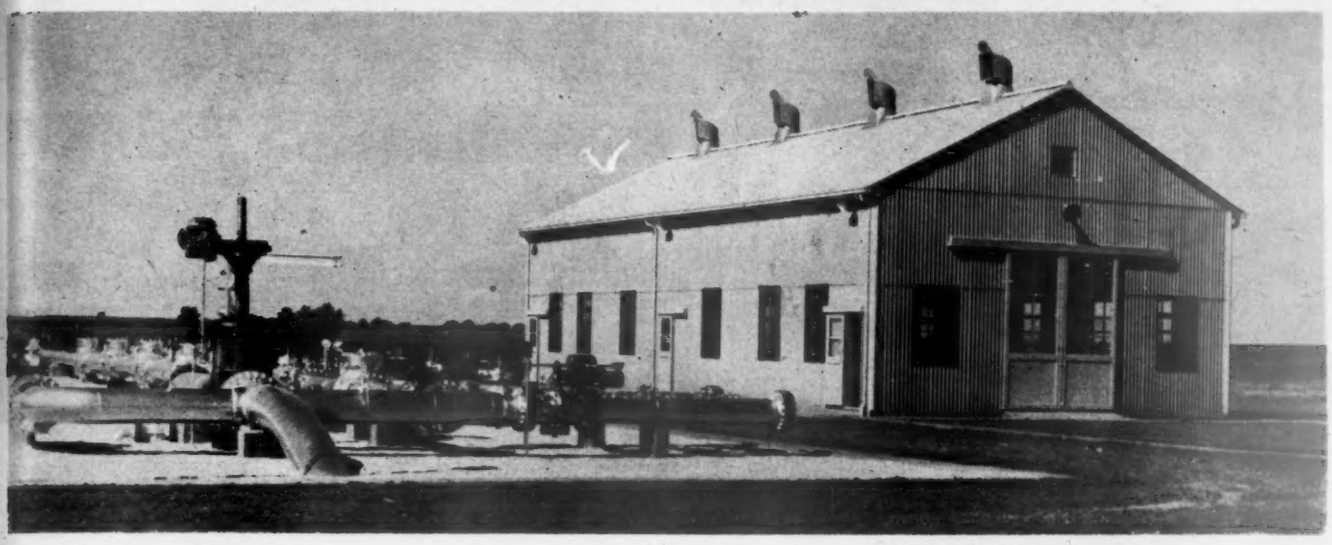


T. D. Williamson, Inc.

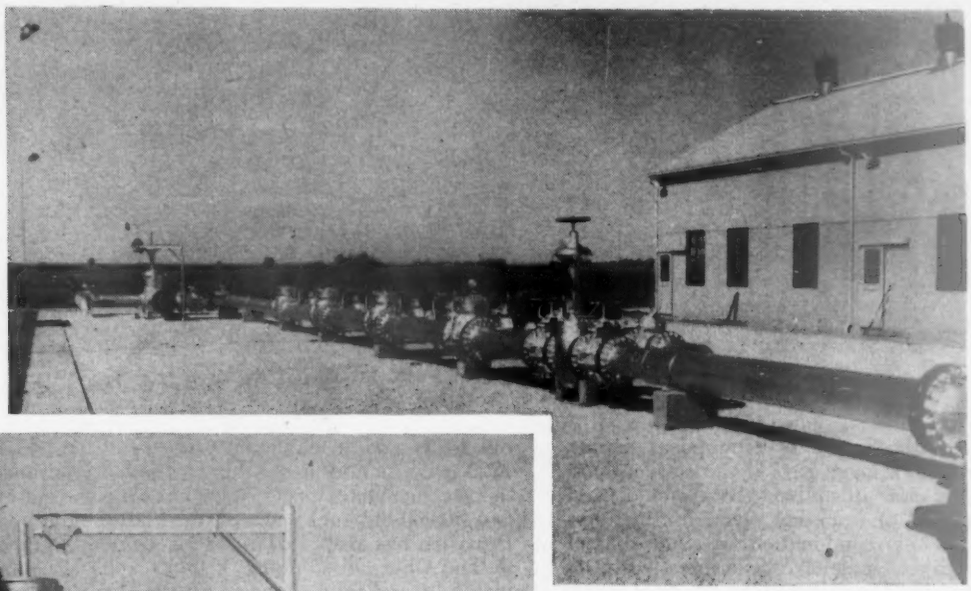
THE PIG WITH THE POKE
CLEANS PIPE LINES

P. O. BOX 4038
TULSA 9, OKLAHOMA

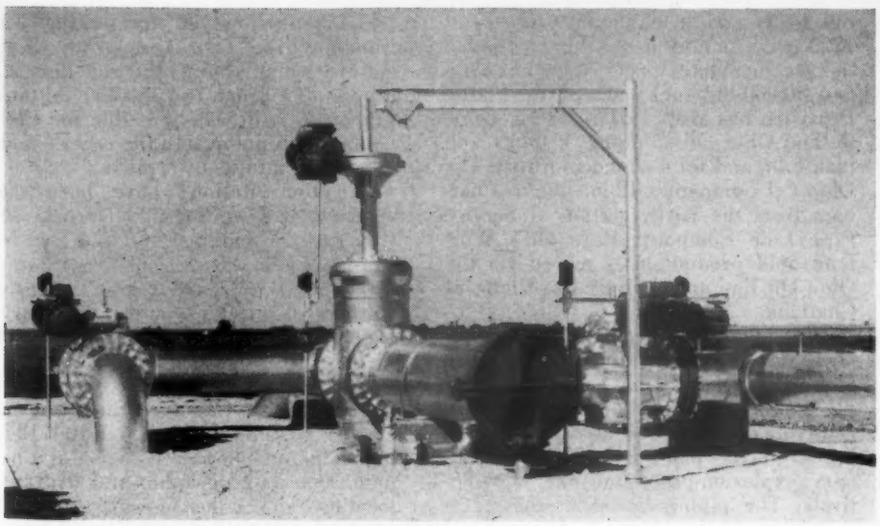
© 1948



Main pump building and manifold at Marysville, Kansas.

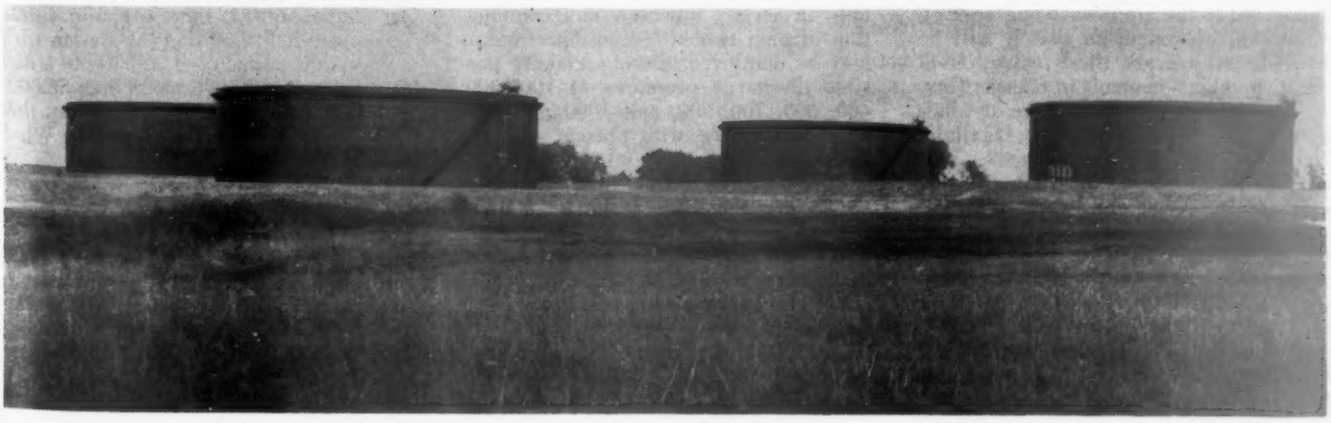


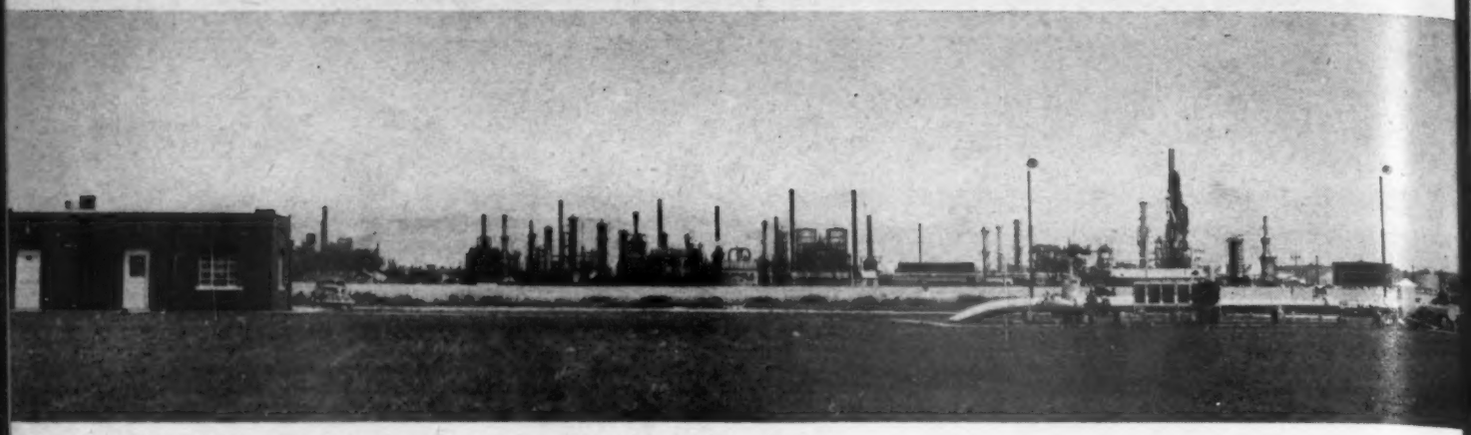
Below, scraper trap installation.



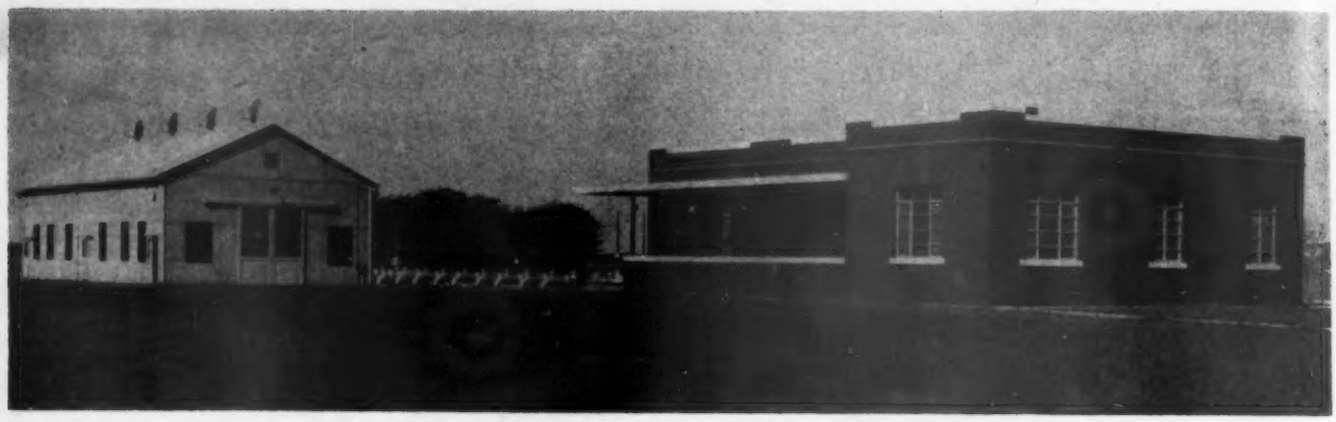
Suction and discharge piping at Marysville, Kansas.

Crude oil storage tanks.





Wood River, Illinois, station, terminus of system. Refinery in background.



General view of the Salisbury, Missouri, pumping station.

With an eye to economical maintenance, a large part of the station manifold was installed aboveground, supported on concrete piers. Strainer barrels or combination strainer barrel-scraper traps have been installed in the manifolds of all stations. Vertical centrifugal low pressure, high capacity pumps were installed in all tank manifolds to assist in the transfer of crude from tank to tank or to boost the suction pressure to the main line pumps. The sump tank at each station is equipped with controls to start and stop the pump automatically when the liquid reaches a pre-set level. A differential pressure orifice type flowmeter also is included in each manifold. All suction and discharge valves and other major valves are equipped with motor operators, which are connected to the control panel. The main block valves at each station are also connected to the microwave-operated remote control system so that it will be possible to operate these valves from the dispatcher's controls in Kansas City.

Main line pump stations are at Chatham and Casper, Wyoming; Ogallala, Nebraska; Marysville, Kansas, and Salisbury, Missouri. Chatham is the originating station and operates on the 16-in. segment, with the others operating on the 20-in. line.

The Chatham Station is equipped with five parallel connected 12-in. horizontal duplex piston pumps, V-belt connected to 200-hp explosion-proof motors. Maximum station capacity, using 5 pumps with 4½-in. liners, is 43,320 bbl a day with a maximum pressure of 1225 psi. The tank manifold is arranged to accommodate one 55,000-bbl and two 80,000-bbl tanks owned by Platte. Provision has also been made for a line to The Ohio Oil Company's tanks and manifold, and for a connection with The Ohio Oil Company's 12-in. line to Chatham from the Kirby station of Service Pipe Line Company. Pure Oil's Worland field production is moved via the Ohio Oil line and delivered to Platte at Chatham.

The pumping facilities at Casper, Ogallala, Marysville, and Salisbury are identical in that all have one 10-in. single stage and three 8-in. single stage centrifugal pumps, powered by one 350-hp, 1760-rpm and three 800-hp, 3560-rpm explosion-proof motors, respectively. The piping layout at these stations permits the pumps to be operated only in series; however, any combination of one, two, three, or four pumps may be employed, thereby making possible discharge pressures of 100, 300, 400, 600, 700, 900, and 1000 psi. This highest pressure, with present stations, will produce a flow of 100,000 bbl a day.

Casper's tank farm is the largest of the system, consisting of ten 120,000-bbl tanks and one 1000-bbl truck unloading tank. The tank manifold also provides connections with Service Pipe Line Company, Sinclair Pipe Line Company, and two additional connections for future use.

Salisbury station is similar to Casper except that there are only four 120,000-bbl tanks; however, by uniting with Sinclair Pipe Line Company's "Key" station, which adjoins the Salisbury station, and at which two 150,000-bbl tanks are being built, it is possible for either company to pump into the other's tanks as well as into its own tanks.

Injection stations have been constructed at Lost Cabin, Glenrock, and Guernsey, Wyoming, and Gurley, Nebraska. Each station consists of two or three pumps designed to inject expected volumes of oil at pressures sufficient to overcome the main line pressures at their respective injection points.

The high viscosity of the oil to be injected at Lost Cabin required the use at this station of three parallel 12-in. piston pumps similar to those at Chatham. Due to geographic and hydraulic location (55 miles downstream from Chatham) required injection pressures are slightly lower; therefore, 5-in. liners were installed providing the station with a maximum capacity of 32,830 bbl a day at a pressure of 1000 psi. Three 55,000-bbl tanks have been provided at this location for receiving oil from the Wind River Basin.

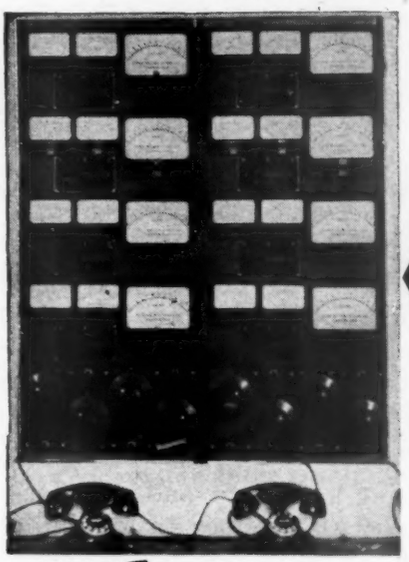
The injection station at Glenrock presented a different problem. Here light sweet crude injected at a point only 27 miles downstream from Casper and 26 miles upstream from a different rise in elevation. It was necessary to parallel two high pressure 4-in. centrifugal six-stage pumps driven by 400-hp, 3550-rpm explosion-proof motors to obtain a pumping capacity of 31,880 bbl a day

Platte Pipe Line Company uses "VAREC" Automatic Tank GAUGING

Explosion proof design for high and low pressure tanks

PUMP HOUSE RECEIVER

Explosion proof, multi-tank, gives INSTANTANEOUS, *continuous gauge of selected tank*



LABORATORY RECEIVER

Multi-tank gives simultaneous, continuous gauge of all tanks. High and low level alarms and pump or valve controls can be set to suit.

"VAREC" ELECTRONIC GAUGERS have been proved again and again in Pipeline Station and Terminal Service!

The increasing number of "Varec" Electronic Gauger installations testify to the benefits obtained from centralized gauging with proper equipment.

For example, one operator required that his laboratory maintain absolute control over products stored in all tanks and that his pump-house control the tanks being pumped. A panel of "VAREC" Receivers with high-low level alarms in the lab now permits his men to take gauge readings of any or all tanks simultaneously. If other duties require their attention, the alarm system instantly notifies them of dangerous levels. His pumpers can gauge any selected tank on a Receiver in the pump house. Both laboratory and pump house receivers are connected to the same tank transmitters with a minimum amount of wiring to make this a practical and economical installation.

You too, can apply "VAREC" Electronic and automatic gauging to your oil movement and storage problems. Costs are lower than you might think.

Call in a "VAREC" representative today

PROVED and APPROVED "Varec"

THE VAPOR RECOVERY SYSTEMS COMPANY
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at a pressure of 1000 psi. No tanks were erected at this station, the suction line being connected directly to the tanks of Continental Oil Company.

Possible operating requirements at Guernsey and Gurley became so numerous that it was necessary that the stations be quite versatile. The piping arrangement, therefore, was designed to allow both stations to operate one pump or both pumps in parallel or series. At Guernsey, the two 4-in. centrifugal four-stage pumps with 400-hp, 3550 rpm motors, when operating in parallel, will move 75,420 bbl a day at a pressure of 490 psi, or when operating in series, 37,-710 bbl a day at a pressure of 980 psi. Platte tankage at Guernsey consists of two 55,000-bbl tanks. A suction and delivery line has been laid to Rocky Mountain Pipe Line Company tanks and provisions have also been made to receive deliveries from the pipe line of Utah Oil Refining Company.

Gurley station presented a problem of high capacity with low pressure, thereby allowing the installation of two 6-in. centrifugal single stage pumps powered by 400-hp, 3550-rpm explosion-proof motors. These high capacity pumps when operating in parallel will move a maximum of 99,500 bbl a day at a pressure of 250 psi, or if connected in series, 49,750 bbl a day at a pressure of 500 psi. Storage available at this station consists of four 55,000-bbl tanks. In addition to servicing the four tanks, the tank manifold was constructed to receive oil from The Ohio Oil Company and the Sterling Pipe Line System.

In addition to the stations discussed, scraper trap installations were built at Yoder, Wyoming; Holdrege, Nebraska; Gower and Montgomery City, Missouri, and were placed and laid out in such a manner that they can be converted into main line stations when additional pumping capacity is required.

The installation at the terminus of the line at Wood River, Illinois, provides for delivering north and east and direct to the Ohio Oil Company pump stations and Sinclair's refinery. There is also a connection to the Magnolia Pipe Line Company at this terminal.

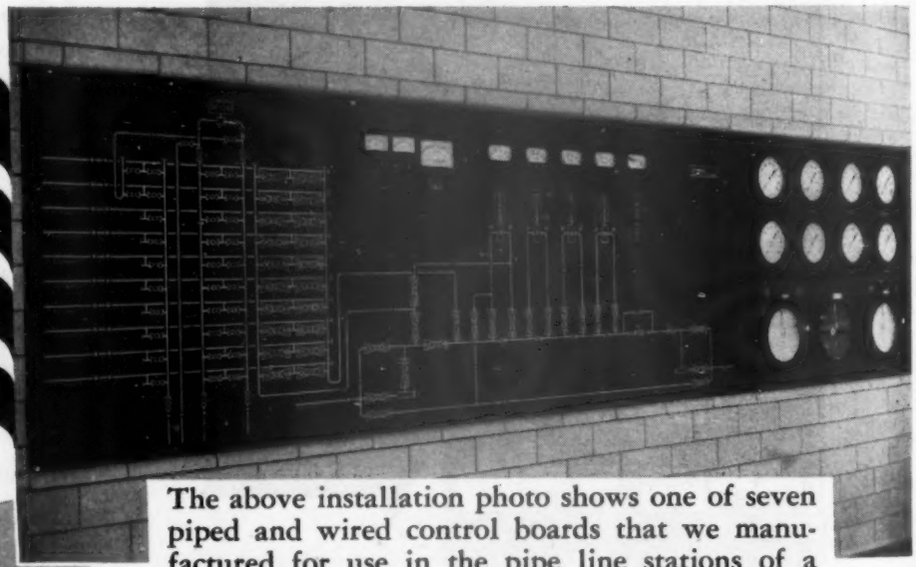
The Western District headquarters office, warehouse, and garage building were built on the station site at Casper. The type of construction is similar to the control buildings except that the building is l-shaped, being 120 ft by 48 ft on one side and 100 ft by 36 ft on the other side. The garage section contains six stalls, a loading dock, and mechanic's workshop. The warehouse section is 48 ft by 36 ft. Steel trusses and purlins with a precast concrete roof was used in the warehouse and garage. The office section is built around a center hallway with five offices, a reception room, stationery room, boiler room, and two toilets opening from the hallway. The office section is finished with plaster walls, acoustical tile ceiling and asphalt tile floors.

Beatrice, Nebraska, was chosen as the location of the Eastern District headquarters. A rectangular brick building, 120 ft by 48 ft was erected, using a preformed metal decking as a roof base. Three stalls were built into the garage section along with the loading dock and mechanic's workshop. The warehouse section was constructed 31 ft by 48 ft. The office section, finished similar to the building at Casper, was located along two sides of the building with four offices, a reception room, stationery room, boiler room, and two toilets opening from the T-shaped hallway.

The Poling and Bacon Construction Company of Toledo, Ohio, built all the stations except the Wood River Terminal, which was built by the R. & R. Construction Company of Alton, Illinois. Cahill-Mooney Construction Company of Casper built the Western District headquarters building, and the Great Plains Construction Company of Fairbury, Nebraska, were the contractors on the Eastern District headquarters building. The tanks at Chatham, Lost Cabin, and Casper were manufactured and erected by Chicago Bridge and Iron Company and are the Horton pontoon-type floating roof tanks. Graver Manufacturing Company was the contractor and supplied center-weighted pontoon-type floating roof tanks at Gurley, Guernsey, and Salisbury stations.

Resident station attendants at the Guernsey, Gurley, Ogallala, and Marysville stations will have one and one-half story expandable, four room-six room cottages. The contractor on all of these is the Jenson and Ridge Construction Company of Wichita, Kansas. * * *

CUSTOM-BUILT
CONTROL BOARDS
For PIPE LINE
STATIONS



MANUFACTURERS OF:
Instrument Panels, Control Desks and Consoles.
Explosion-Proof Motor Starters, Circuit Breakers, Push Button Stations, Lighting Panels and Junction Boxes.
Low Voltage and High Voltage Switchgear.
Pipe Line Samplers, Locators, Coating Inspectors, Rectifiers and Flange Insulation.

The above installation photo shows one of seven piped and wired control boards that we manufactured for use in the pipe line stations of a major pipe line company; fourteen gauge boards also were furnished.

"NEMCO" engineering know-how and manufacturing skill are geared to produce custom-built electrical equipment which is designed to meet each customer's specifications.

NELSON Electric MANUFACTURING CO.
TULSA, OKLAHOMA
217 N. DETROIT AVE. TELEPHONE 2-5131

1,075 E-I-M Controlled Miles*

* From Worland, Wyoming, to Wood River, Illinois —1,075 miles, it is ***E-I-M*** all the way.

Some unique engineering steps were pioneered on the Platte Pipe Line, which covers five states and crosses two of the largest rivers in the United States, the Missouri and the Mississippi. It is one of the largest and longest crude oil carriers ever constructed, with 14 pumping stations along the line, and E-I-M Valve Controls are being used exclusively from end to end. There are more than 200 E-I-M Valve Controls of various types on this 16" and 20" line.

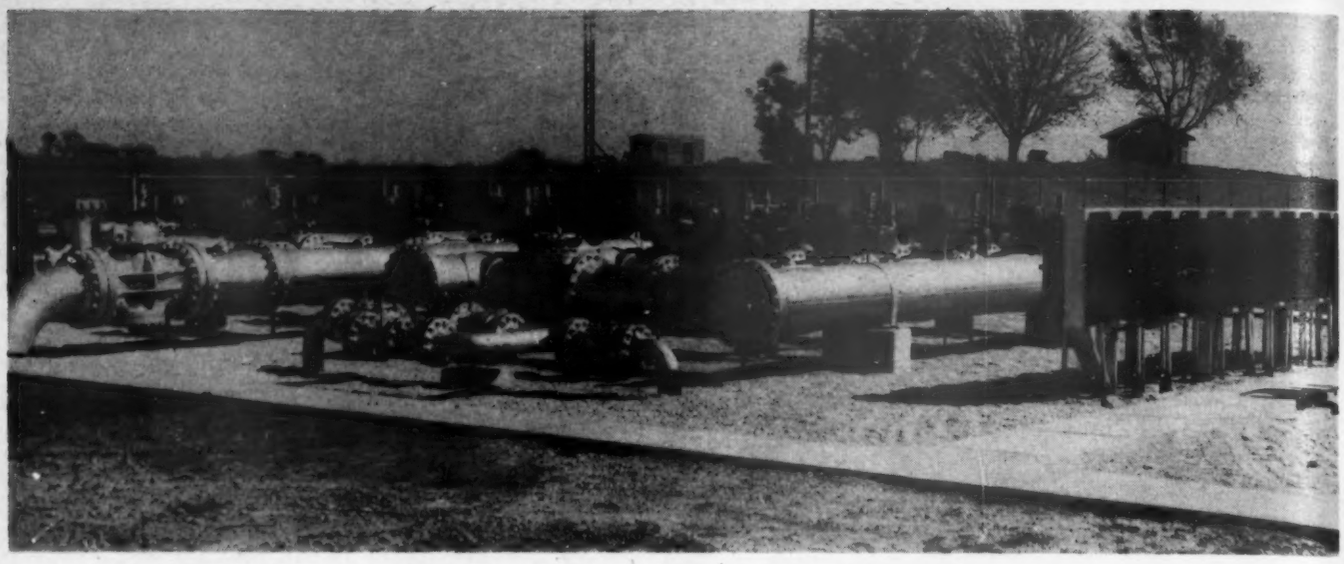
All over the world, ***E-I-M Valve Controls*** are the guardians of the oil and gas industry's life lines, of which the new Platte Pipe Line is a mighty artery.

Progressive Pipe Liners Specify E-I-M VALVE CONTROLS

E-I-M Company INCORPORATED

1340 OLD SPANISH TRAIL • HOUSTON 21, TEXAS • MOhawk 4587

Valve Controls • Speed Reducers • Cooling Tower Drives • Control Valves



Manifold for transferring oil to and from tankage, and to Sinclair pump station on adjoining site.

P 615.

System Features Advanced Engineering

Collective experience and ingenuity of engineering committee place Platte as a forerunner in "pushbutton" pipelining for large systems

K. T. FELDMAN

After several years of consideration by nearly all major oil producing companies in the Rocky Mountain area, five of the major oil companies solidified their efforts and organized the Platte Pipe Line Company on August 1, 1950. The stockholders are The Ohio Oil Company, Sinclair Pipe Line Company, Continental Oil Company, The Pure Oil Company, and British-American Oil Company, Ltd.

Shortly after its inception, each of the stockholder companies appointed one or more members to the Platte Engineering Committee. This engineering committee held its first meeting in New York City on August 21-23, 1950.

The committee was vested with the authority to approve all preliminary engineering, design, material requisitions, and construction contracts during the initial planning and construction phase, and acted as consulting engineers for the Platte project. During the balance of 1950 and until September, 1951, this committee held monthly meetings to advise and recommend appropriate action to the Platte engineers in their work. By September, 1951, most of the engineering and design had been completed, and all major contracts let. It was then decided that Platte engineers could successfully complete the project without assistance, and the last regular engineering committee meeting was held at Casper, Wyoming, on September 6, 1951. The committee was then placed on an advisory status subject to be called upon as needed.

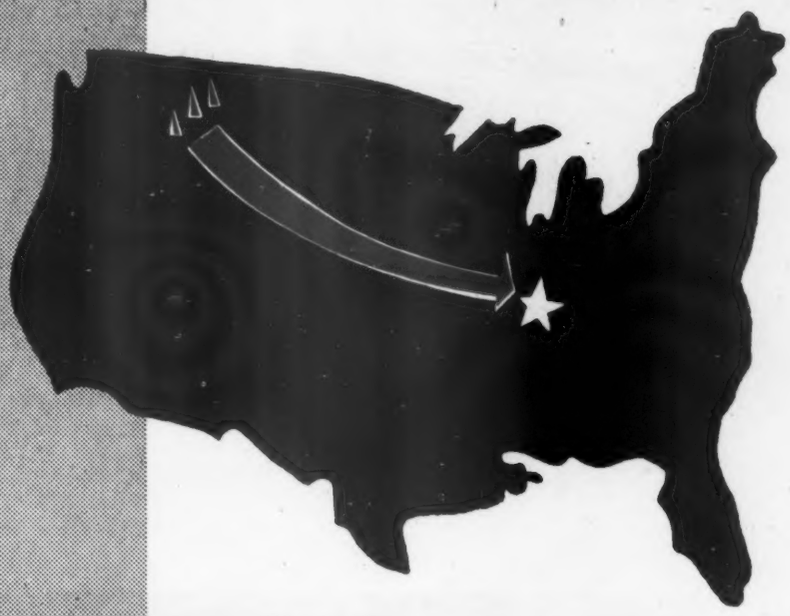
During these meetings, future plans and specifications for pipe lines and pump station construction were discussed and approved. The successful completion of Platte Pipe Line is in a great measure due to the untiring effort and hard work of the Platte Engineering Committee. Most of the members have spent their lifetime in the pipe line industry. Some had considerable experience in storage tanks, another in pumps, and another in communications, and many interesting and profitable discussions developed. It is not unusual that the cumulative desires of the members of this committee would result in incorporation of many unique ideas and entirely new design features; many of which have been tried and proved, but several ideas are entirely new and are being pioneered by Platte.

There has been a definite trend toward electric-powered pump stations in the last 10 years. Readily available electric power and reasonable power rates made all electric pump stations a definite advantage on the Platte system.

The Author

K. T. Feldman, chief engineer of Platte Pipe Line Company, was graduated from the University of Kansas in 1933 with a BS degree in mechanical engineering. He was inspector for Kansas Highway Department, 1933-35, when he was employed by the Sinclair Pipe Line Company as engineer in the crude oil department. In 1940 he was assigned to the products pipe line department, working on design and construction. Entered the U. S. Army, Corps of Engineers, in 1942, and holds a captain's reserve commission. Upon return from the Army in 1945, he was assigned to the general office of the Sinclair Products Company in Columbus, Ohio, as assistant chief engineer. In September, 1947, he was transferred to Marion, Ohio, as division engineer for eastern division products lines, and in September, 1950, was made chief engineer of Platte. He is a member of NACE and a registered professional engineer in the states of Ohio and Kansas.

THE PLATTE PIPE LINE

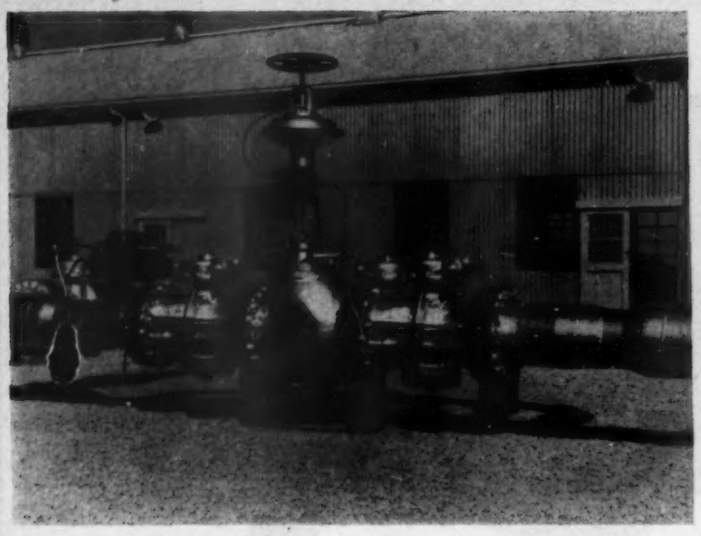


551 miles 16 and 20 inch from Worland, Wyoming to Holdredge, Nebraska built with one spread by R. H. Fulton & Co.

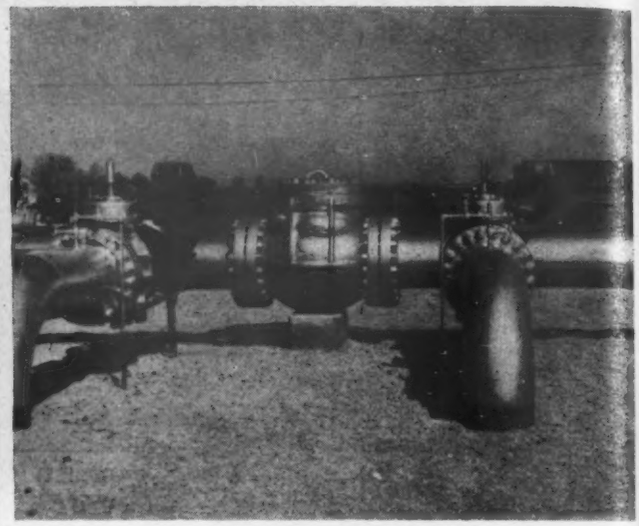
Holdredge, Nebraska, to Kansas state line, 139 miles, built by Fulton and Bodie, Inc.

R.H.FULTON & COMPANY

LUBBOCK, TEXAS



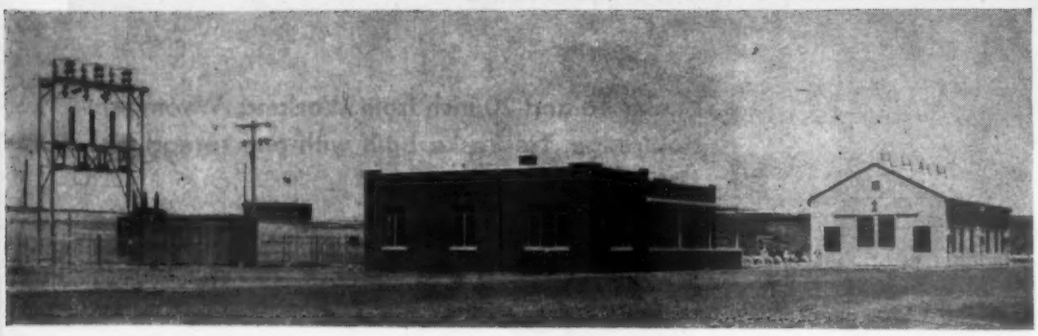
Pressure control equipment.

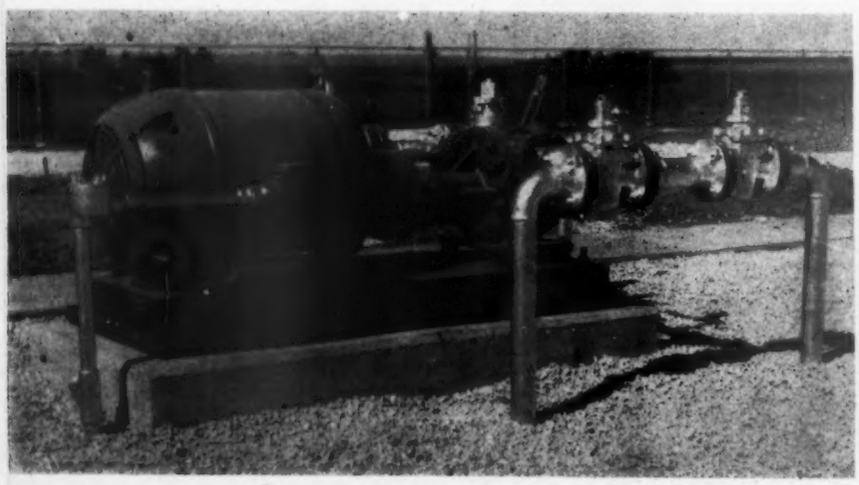


Check valve between station suction and discharge.

Interior of warehouse at Casper, Wyoming, at which point there is a mainline station and district headquarters.

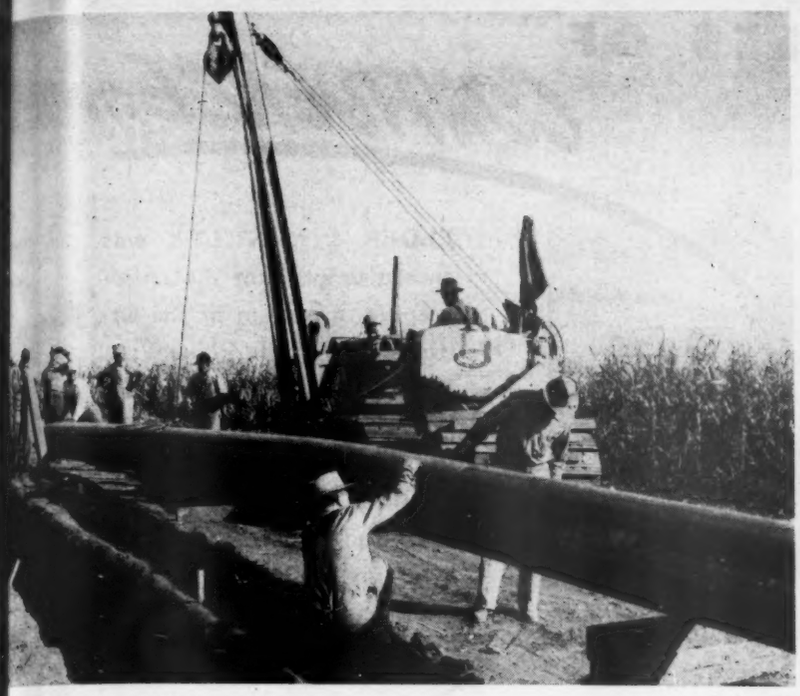
General view of Casper, Wyoming, station.





Sump pump driven by 15-hp motor.

Tail gate valve at Salisbury station.

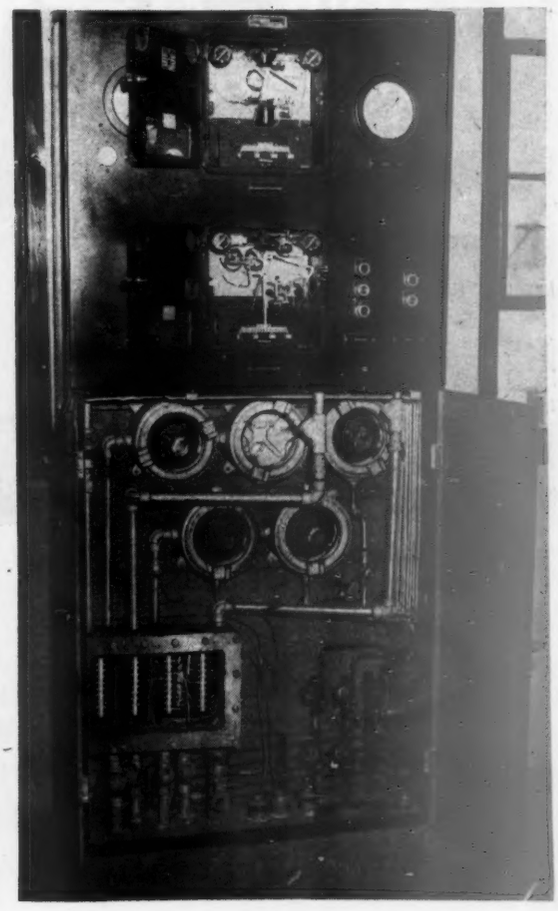


Lining up pipe preparatory to running the stringer bead.

Making Kaiser pipe, a part of which was used on the line.

With the pipe cleaned and primed, the coating and wrapping machine can be seen coming over the rolling Kansas countryside.

Interior of discharge pressure controller and transmitter.



1100 MILES OF CONFIDENCE...

WYOMING

ELDER & McNULTY was chosen to perform the radiographic inspection of the entire length of the Platte Pipe Line running from Worland, Wyoming to Wood River, Illinois. We are proud of having been given this assignment and to have completed it on time.

ILLINOIS

Radiography assures the pipe line owner of a greatly improved quality of welding by non-destructive testing and reduces expenses by eliminating the necessity of making many costly cut-outs, especially on large diameter, high yield pipe.

Write for FREE Folder on Radiographic Pipe Line Inspection.

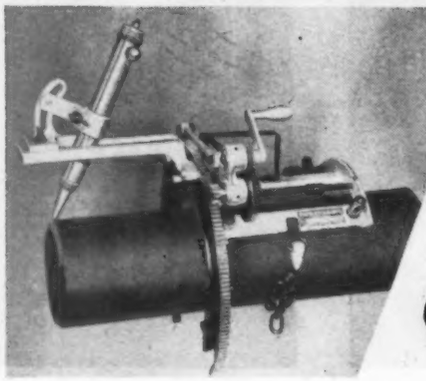
ELDER & McNULTY THOMPSON BLDG. • TULSA, OKLA.

BEVELED BY H&M

Hats off to the men who laid the 1,075 mile Platte Pipe Line! They have once again proven that the economy and speed of the H & M Pipe Cutting and Beveling Machine helps meet the toughest of construction schedules.

Lightweight, easy to handle, set up, and adjust, the H & M gives a neat, clean homogenous cut and bevel every time. Simple thumb screw settings allow the torch to be fixed at any desired beveling angle. The unique H & M "Out-Of-Round" attachment eliminates costly "truing" of the pipe. A roller torch-guide leads the torch around the "Out-Of-Round" contour giving a continuous and accurate bevel for the entire 360° circle.

Remember, there is only one H & M . . . it is offered in five models, capable of handling from 4 to 36 inch diameter pipe. For full engineering specifications and current prices, write



H&M **PIPE BEVELING CO.**

311 E. 3rd • Tulsa, Okla.

Phone 3-0241

Air compressors and tank (left), and Lectrodryer for dehumidfying pressure control lines.

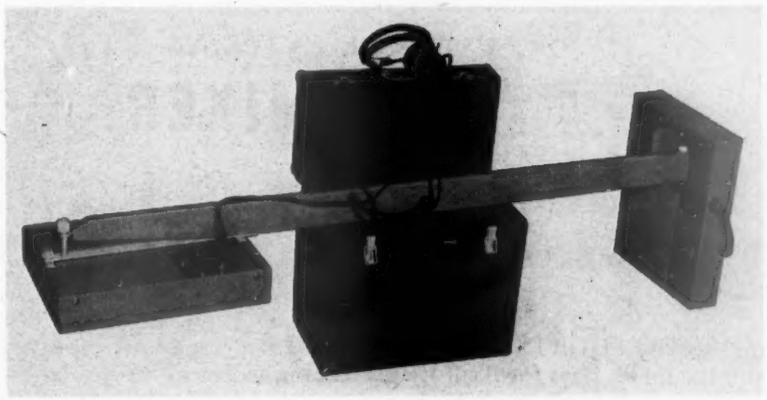
Tube type explosion-proof main line motors are utilized throughout and are controlled by outdoor switchgear and unit type substations. Remote control boards are located in control buildings a short distance from switchgear and pump buildings where all pumps and motors may be controlled, and all motor-operated valves controlled in conjunction with a schematic diagram of the station piping. This type pump station lends itself very well to automatic operation, which is the primary factor in Platte station design.

The 20-in. section of line from Casper, Wyoming, to Wood River, Illinois, has been repeatedly called the "down hill" pipe line due to the fact that the Casper station is one mile above sea level and Wood River is about 430 ft above sea level. This elevation head would cause a gravity flow of 40,000 bbl per day if the oil were pumped over the first hill east of Casper station. On the other hand, the static pressure at Wood River would be about 2000 psi if a block valve at Wood River were to be closed. This static pressure is much greater than the yield strength of the 20-in. X-52 pipe and causes a difficult problem to shut the line down and still keep the pipe line filled with oil.

One of the unique design features of the Platte system is the installation of underpressure regulator valves at Yoder, Wyoming, Ogallala and Holdrege, Nebraska, Marysville, Kansas, and Gower, Missouri, which automatically close in sequence from the uphill station when the line is shut down. A typical regulator station consists of two 8-in. air-loaded S-type regulator valves connected in parallel with one 6-in. air-loaded relief valve. The relief valve is set to close at a pressure equivalent to the upstream static head at that point. The regulator valves are set to close at a pressure 10 to 20 psi higher than the relief valve pressure. A typical operating sequence would begin by shutting down all stations except Casper, the originating station. Casper would then shut down, lowering the line pressure at Yoder, the first regulating station. When the line pressure at Yoder drops to the operating pressure of the regulator valves, these two valves close, allowing the line surge to flow through the relief valve until the gravity flow through the relief valve lowers the line pressure to the operating pressure of the relief valve and the relief valve then closes, holding sufficient pressure on the upstream side to keep the line from Yoder to Casper filled with oil. The downstream pressure continues to drop until the operating pressure of the next regulating station at Ogallala is obtained, leaving the section of line between Ogallala and Yoder filled with oil. These five regulator stations on the down hill section of the line will keep the line filled with oil at all times, eliminate a serious air problem, and reduce contamination between the interface of batches of various types of crude. Upon shutdown of the entire line, the total static head will be divided into increments of 300 to 400 psi. The regulators automatically open when the uphill station resumes pumping and raises the line pressure above the closing pressure of the regulators. If the regulators fail to close and excessive static pressure is developed in the line, an emergency relief valve and bursting head will re-

THE WILKINSON LINE LOCATOR

This is the Line Locator that Platte Pipe Line Company used on their Wyoming-Illinois project to spot subsurface obstructions, particularly in congested areas.



This electronic sleuth is being used on many of the important pipe line jobs. It determines placement and depth of pipes, cables, etc. The Wilkinson Line Locator is a dependable instrument built for tough jobs.

WILKINSON PRODUCTS COMPANY

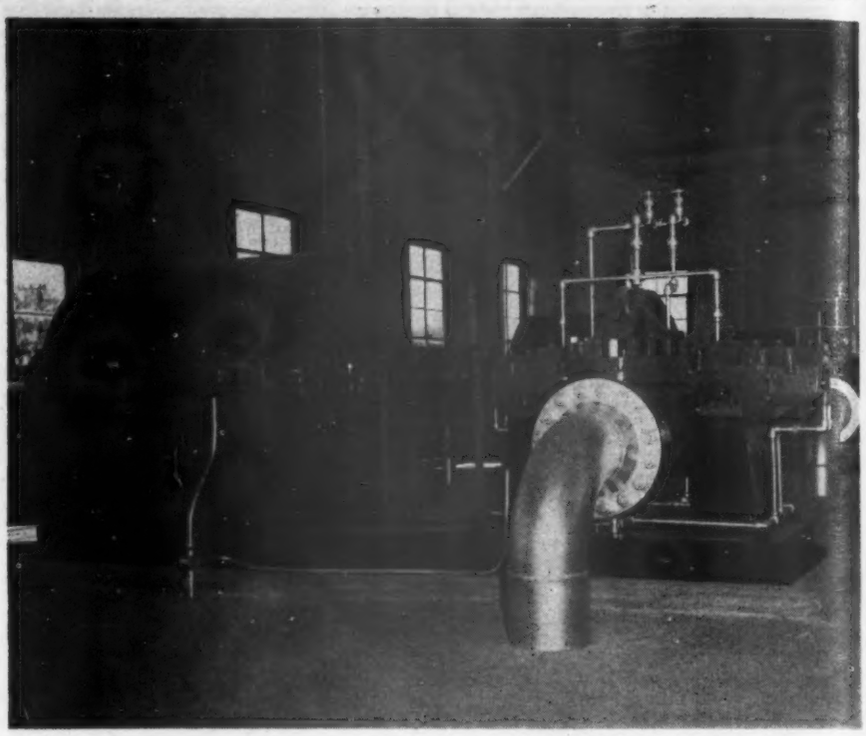
3987 Chevy Chase Drive — Pasadena 3, California

Telephone: Sylvan 0-4314

lieve the line fill into working storage tanks at Salisbury station.

API grade 5LX-52 pipe was used on all Platte trunk lines. The section of 16-in. line from Chatham to Casper, Wyoming is designed to operate at a pressure of 1200 psi and is of 9/32-in. wall, 47.22 lb per lineal foot, double random length, electric weld pipe supplied by Kaiser Steel Corporation. This pipe was tested at the mill at 1560 psi with a minimum yield of 1600 lb per sq in. This section of 16-in. pipe line is not telescoped.

The 20-in. pipe line from Casper, Wyoming to Wood River, Illinois, was laid out hydraulically for eight pumping stations with four being constructed on the original installation. Scraper traps are constructed at future stations with the same piping manifold as present stations and future stations may be added without shutdown of main line. Pump stations on the 20-in. pipe line are designed to operate at 1000 psi. The pipe line on the discharge side of each present and future station is 20-in. OD, 11/32-in. wall, 72.16 lb per lineal ft, double random length, electric weld supplied by Kaiser and A. O. Smith Corporation. This pipe was tested at the mill to 1520 psi with a minimum yield of 1560 psi. The length of heavy pipe on the discharge of each station was determined from a hydraulic gradient of the line using a safety factor of 1.8, and the length of heavy pipe varies from 72 miles on the discharge side east of Casper to 12 miles on the discharge side east of Monte station, Missouri.



Pumping units—800-hp motors driving centrifugal pumps at speed of 3550 rpm.

The remaining portion of the 20-in. pipe line between each station consists of 5/16-in. wall, 65.71 lb per lineal ft, double random length, electric weld, supplied by A. O. Smith and Youngstown Sheet and Tube Company. This pipe was tested at the mill to 1390 psi with a minimum yield of 1420 psi. Reject pipe was used for tank lines and casing.

Adequate working storage is provided at injection stations and at Casper, Wyoming, where the oil is stored to allow proper batching of various types of crude. It is planned to pump and keep separate three types of crude oil. A special type bottom outlet was designed in order to allow the maximum efficient usage of the total tank volume, and switch tanks to any of the three types of crude with minimum contamination. Separate fill lines were constructed to each tank to further eliminate contamination and allow switching of tanks from the station suction manifold.

Four 6-in. nozzles are placed at 90-deg spacing around the tank 1 ft off the bottom and at a 60-deg angle with the shell. These nozzles are connected to the fill line so that four jet streams impinge on the bottom of the tank to reduce accumulation of bottom sediment. All tanks are pontoon type or pan type floating roof with a specially designed gaging tube so that hand line gages and sampling can be made from the top of the tank. Remote reading electronic gages are provided on all tanks, with the receiver in the control room at the pump station. It is planned to make all hourly checks with electronic gages. As no one tank can be segregated for sweet crude exclusively, all tanks are coated on the interior. The underside of roof,

eliminate *Costly*
storage TANK CLEANING
with a SHORTSTIR*
SIDE ENTERING
MIXER

The SHORTSTIR Mixer, installed in crude oil pipe line storage tanks, pays for itself by preventing sediment accumulation. It eliminates costly tank clean-out . . . down time for clean-outs . . . loss of marketable oil . . . makes chemical treating unnecessary in most cases or improves efficiency of treatment where required . . . and maintains maximum storage capacity. Installation usually costs less than one clean-out and yields appreciable future savings.

For a rugged, dependable, trouble-free mixer — specify SHORTSTIR.

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Write for Literature

SJR

SAWYER-JENSEN-ROSS CO.

BOX 3156 WHITTIER STATION TULSA 4, OKLAHOMA

Tank level transmitter on remote reading electronic gage.

rimplates and 18 in. of the bottom ring are painted with four coats of vinal paint. The bottom is coated with a 3/8-in. minimum thickness of reinforced coal tar enamel.

A microwave communication system was chosen for the Platte line to provide sufficient circuits for dispatching, administration, and supervisory control of line and pump stations. Nine channels are provided in the original installation with VHF radio communication for mobile-to-mobile and mobile-to-district office communication. The channels are assigned as follows:

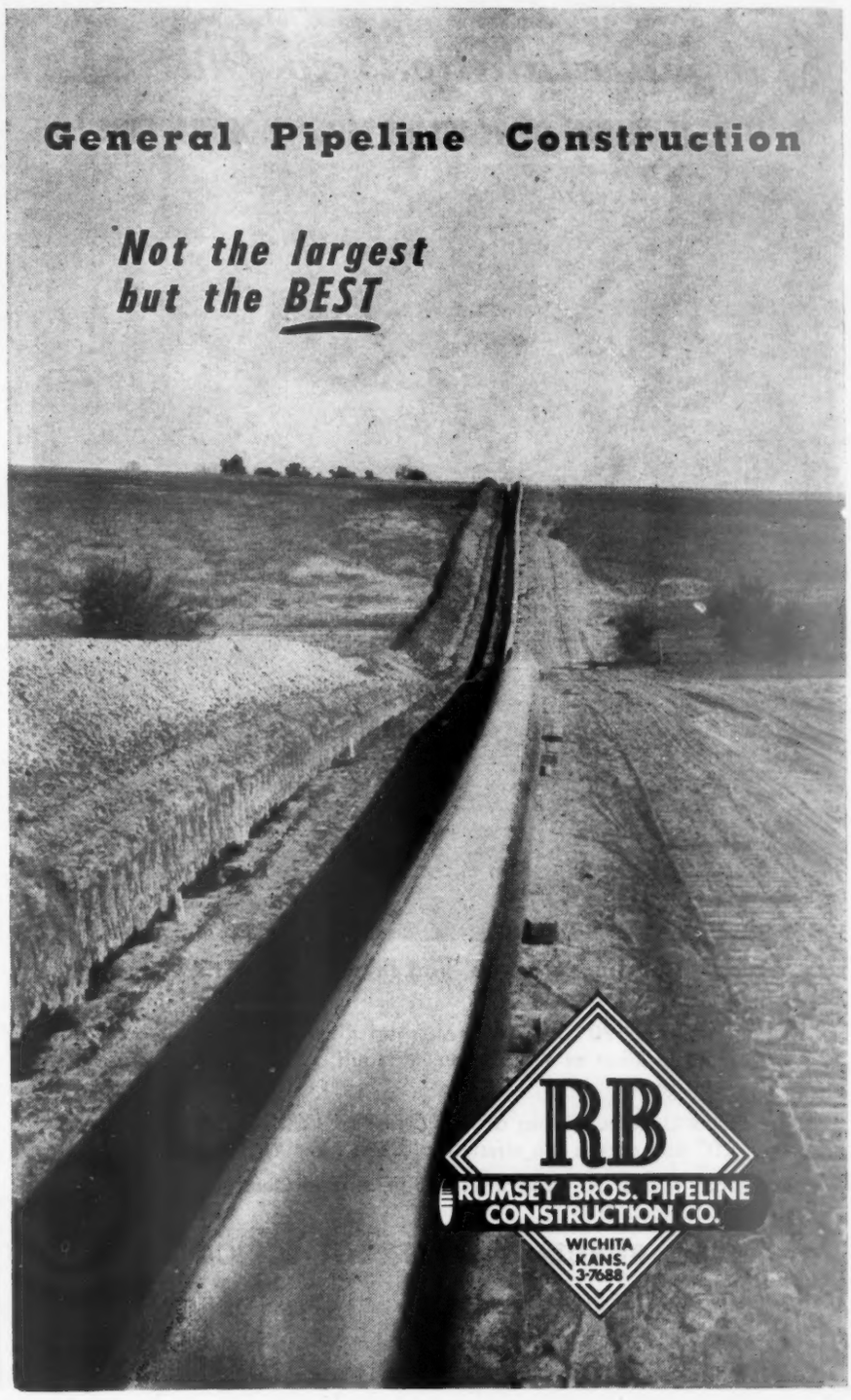
1 Service channel and VHF (joint use)
1 Dispatching circuit (party line ring-down)
2 Circuits to district offices
1 Voice circuit (stockholder)
4 Circuits for supervisory controls and telemetering.

A teletype circuit is superimposed on the business circuit to district offices and Wood River, Illinois.

Forty-four microwave stations are required to span the section from Casper, Wyoming, to Wood River, Illinois, with loops to Beatrice, Nebraska, and Kansas City, Missouri. The towers vary from 60 ft to 300 ft in height and are the single triangular guyed type. Equipment is housed in a precast concrete building at the base of the tower with parabolic reflectors mounted on top of the building. The Kansas City reflector is on the 32nd floor of the Kansas City Power and Light Building where the general office is located. Standby power is provided at each location with standby R-F equipment. Tower light faults, power failures, and R-F equipment faults are transmitted to the dispatching console in the Kansas City general office. Wire communication is provided west of Casper.

All telemetering and supervisory controls are transmitted via four microwave channels to the dispatcher's office in Kansas City, Missouri. Recording instruments for pressure and flow are mounted on metal cabinets on one side of the dispatcher's room. Supervisory controls and instantaneous telemetering are terminated on a large U-shaped console where the dispatcher has easy access to all push buttons and switches. Tank gages and indicating pressures are transmitted to instruments on a panel on the console in front of the dispatcher. VHF controls are also mounted on the console. A separate PBX board on a movable table provides for dispatcher's control of voice circuits after regular office hours.

Because the static pressures developed when the line is shut down are extremely



Primer, coal tar enamel, glass fiber matting, and Kraft paper formed the composite coating.

important, telemetering pressure units are installed at each pump station, and the pressures are transmitted via microwave to recording pressure gages in dispatcher's office. The dispatcher can immediately determine whether all regulators are functioning properly. If the regulators are not properly blocking the stream, it is possible to close remotely one block valve at each main line station. Other pressures at automatic stations can be read remotely on an indicating pressure gage on the dispatcher's console on an "as-called-for" basis. Other telemetering includes gaging of tanks at Guernsey and Gurley, and flow meter reading from Wood River. These values are read on instruments situated in dispatcher's office in Kansas City. Other supervisory controls are start and stop of pumping units at Glenrock, Guernsey, Gurley, Ogallala, and Marysville pump stations, and control of discharge pressure at Glenrock, Guernsey, and Gurley pump stations. It is proposed to operate Glenrock, Guernsey, Gurley, Ogallala, and Marysville stations fully automatic with a resident station attendant to remedy any trouble and to make tank switches and hand line gages for custody transfer of oil.

Station protective devices include over current relays, under voltage relays, and bearing temperature mercoids on main line motors, temperature mercoids on pump case, low suction and high discharge mercoids on main line pumps, automatic sump pumps, and mercoid pressure switch on mechanical seal housing. Main line pumps at automatic stations can be started and stopped by the dispatcher in the Kansas City office by one switch for each unit operating through a sequence control at each station.

The design features of the Platte Pipe Line are the result of combining the knowledge and know-how of many of the foremost pipeliners and is a tribute to their farsightedness to attempt to build and operate tomorrow's pipe line today. * * *

Hardesty Heads AGA Group

D. A. Hardesty, director of the employee and public relations division of the Natural Gas Pipeline Company of America, Chicago, Illinois, has been elected chairman of the American Gas Association Midwest Personnel Conference. A. W. Peel, personnel director, Kansas-Nebraska Natural Gas Company, Inc., Hastings, Nebraska, was elected vice chairman, and Louis Langhus, general plant superintendent, Central Electric and Gas Company, Lincoln, Nebraska, was elected secretary.

Hardesty joined Natural Gas Pipeline in 1931, when construction of long-distance high-pressure natural gas pipe lines was in the pioneering stage. Hardesty was charged with the responsibility of supervising procurement of the right-of-way for the 1400-mile Texas-Illinois gas pipe line.

Congratulations to Platte

FOR CONSTRUCTION OF WORLD'S MOST MODERN PIPE LINE

O. R. Burden Construction Corp. had the privilege of constructing the following:

1) 271 miles of 20" line from Missouri River at Halls, Missouri to the Mississippi River at West Alton, Missouri. Above photo of pipe gang on west section.

2) Parallel Lines consisting of 7,215 feet of 12¾" line and 10,404 feet of 20" line across the Mississippi River near Wood River, Illinois.

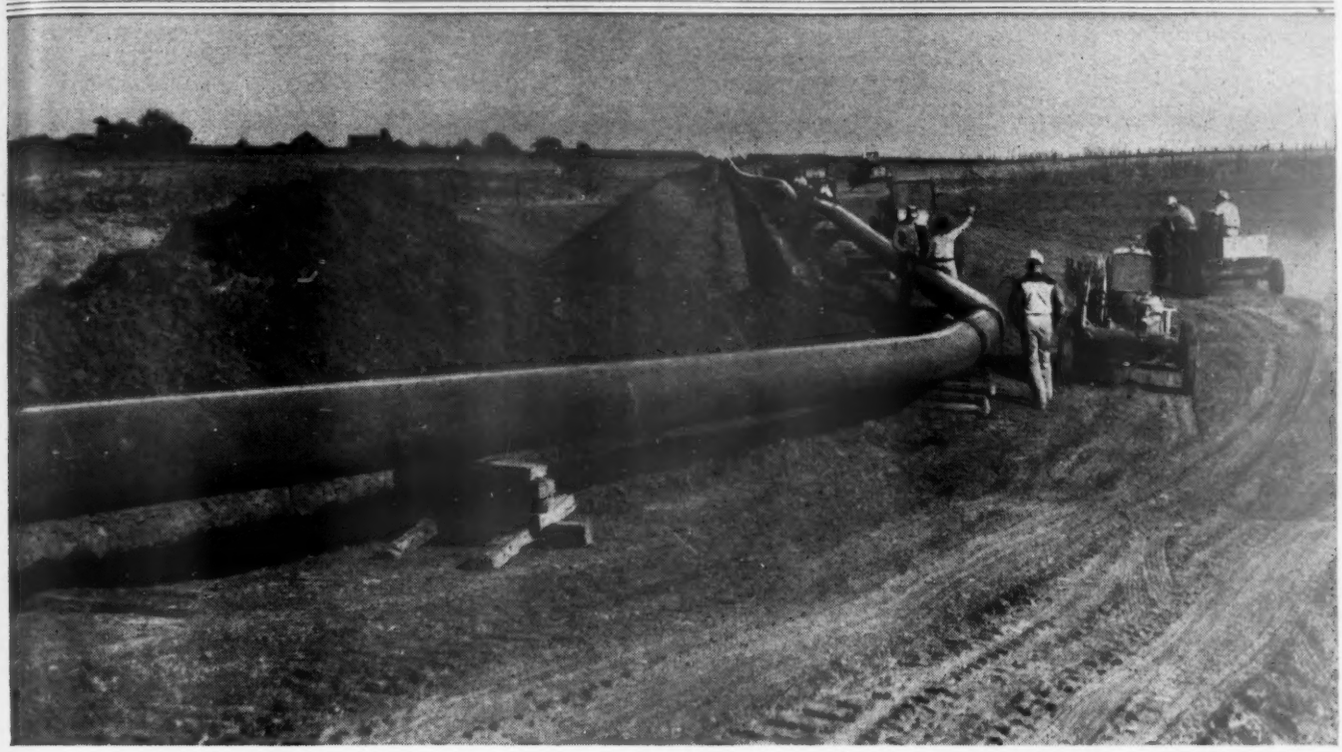
3) 15,159 feet of 20" tank lines to Sinclair and Ohio Refineries at Wood River, Illinois.

O. R. BURDEN CONSTRUCTION CORP.

O. R. Burden, President
P. T. Thibodaux, Vice-President
J. S Burden, Secretary-Treasurer

6702 East 21st St.
Phone 8-3378
Tulsa, Oklahoma

PIPE LINE PROGRESS



20-inch A. O. Smith line pipe being welded on the Rumsey Brothers, contractors, Nebraska spread of the Platte Pipe Line Company's 1,056-mile crude transmission line

Platte Pipe Line . . . New Outlet for Rocky Mountain Crude

A new 20-inch crude transmission main now delivers Rocky Mountain production to refineries at Wood River and Chicago, Ill., Bayshore (Toledo), Earhart (Detroit), Olean, N.Y., and Falling Rock, W. Va.

It is the 1,056-mile line of Platte Pipe Line Company, a Delaware corporation with stock owned by Sinclair Pipe Line Company, The Ohio Oil Company, Continental Oil Company, The Pure Oil Company and Toronto Pipe Line Company.

Big Horn, Wind River, Great Divide and Powder River basins of Wyoming and the Denver-Julesburg basin of Colorado and Nebraska supply the crude from existing producing wells, previously shut-in wells and recently drilled wells. By opening this Rocky Mountain area, new reserves and production from new drilling are now made available.

The pipe line begins in the Big Horn basin near Worland, Wyoming, and stretches in a southeastern direction across Nebraska, northeast Kansas and Missouri. Eastern terminal is Wood River, Illinois, from where other pipelines distribute the crude to refineries to the north and east.

A. O. Smith welded steel line pipe comprises more than half of this 20-inch main, a dominant factor in the completion of another great petroleum pipe line.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

FIRSTS by A.O.Smith: Welded line pipe • Internally expanded pipe • Light-wall large-diameter pipe • World's largest producer of large-diameter welded steel pipe.

The A.O.Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

A.O.Smith

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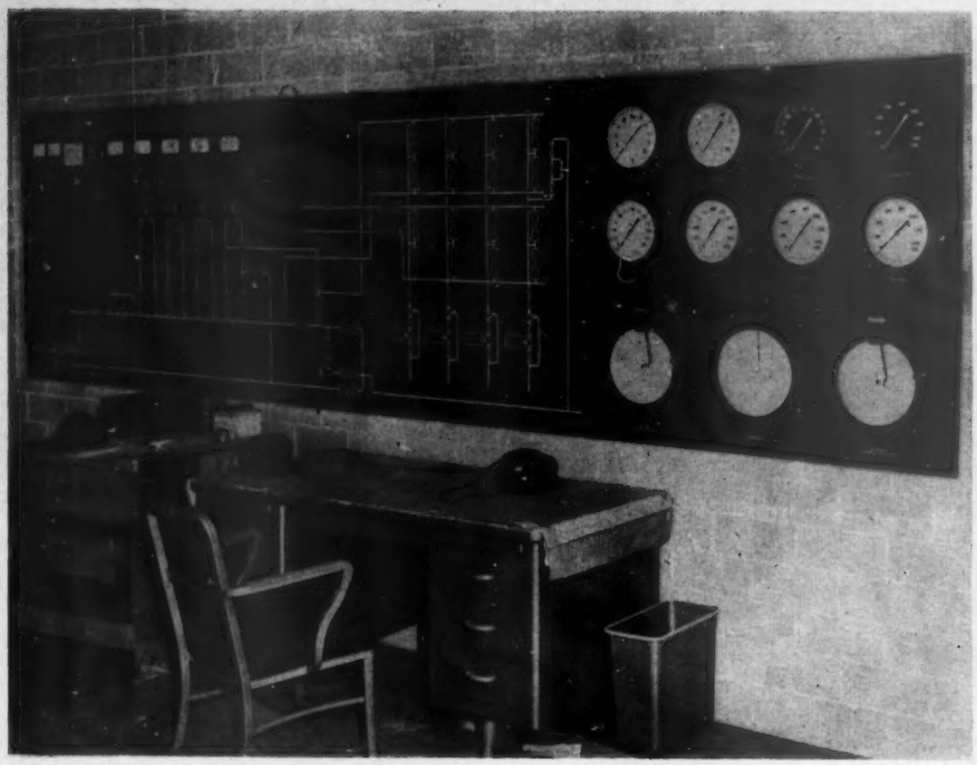
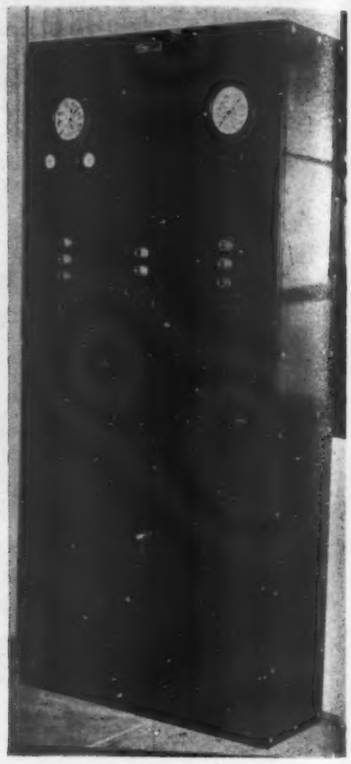
Los Angeles 22 • Midland 5, Texas • New Orleans 12
New York 17 • Pittsburgh 19 • San Francisco 4
Seattle 1 • Tulsa 3 • Washington 6, D.C.
International Division: Milwaukee 1

DEPENDABILITY THROUGH RESEARCH AND ENGINEERING



Control board at Salisbury, Missouri.



Pressure control equipment.

P 516.72

Electrical Design and Construction

Electric motor operations are incorporated in overall building of the system

ALLEN R. HEIDEBRECHT

In recent years, the trend has been toward increased use of electricity as a source of power for oil operations, particularly in pipe line pumping. Electric motor operations were incorporated in the overall building of this modern pipe line system.

It was not considered practical to provide standby equipment in case of power failure, which is expected to be rare.

With one exception, all stations are served at 34.5 or 69-kv with Platte providing a unit type substation consisting of a high voltage terminal structure and air break switch, a three-phase transformer, and cubicle type switchgear. The secondary voltage of the transformers is 2300 delta, the rating of all pump motors. Generally, the switchgear consists of a metering cubicle for power company use, a second unit for control, relaying and surge protection equipment, and a third for a distribution transformer that provides switchgear control power as well as lighting facilities for station buildings. In the next four cubicles are 2300-volt air-blast type breakers for the pump motors, and in the last two units there is an air-blast breaker controlling a 2300 to 480-volt three-phase transformer, which provides power for auxiliary equipment in the form of a 40 to 60-hp booster motor, a 15-hp sump pump, and numerous valve controls.

The need for adequate lightning protection was recognized and met by providing all stations with properly selected station type arresters at the high voltage terminal structure in addition to surge protection equipment at 2300 volts mentioned in the cubicle arrangement. Direct stroke protection was accomplished with the use of extended rods mounted at both ends of the terminal structure considerably above the elevation of any equipment in the immediate area.

To meet electrical code requirements, as well as to provide safe working conditions in a hazardous area, and to eliminate fire walls or costly air ventilation for motors, all pump motors are of the explosion-proof type. Generally, a booster station will consist of one 350-hp and three 800-hp motors. Injection stations may have 200 or 400-hp units.

The Author

Allen R. Heidebrecht, senior electrical engineer for Platte Pipe Line Company,

was born December 26, 1908, in Harvey County, Kansas. Reared and completed grade and high school at Buhler, Kansas, and was graduated from Kansas State College in 1934 with a BS degree in electrical engineering. He was associated with the Kansas Gas and Electric Company in the operating department in Wichita, Newton, and Independence, Kansas, for 16 years. Platte Pipe Line employed him as senior electrical engineer in November, 1950. He is an AIEE associate member, Wichita, Kansas, Section, and a licensed professional engineer in the State of Kansas.

To expedite operations, electric valve controls have been installed on all large size valves. Electrically, they are rated for operation at either 480 or 240-volt three-phase. At the Casper station, 40 valve control units have been installed. At other stations requiring fewer storage tanks and smaller manifolds, fewer operators were installed.

The larger motors, 350 hp and above, are provided with bearing temperature protection. Bulb type temperature relays mounted within ⅛ in. of the bearing surface and adjusted to trip circuit breakers at 75 to 80 C bearing temperature should protect the motors from serious damage in case of oiling failure or other comparable causes.

Substation arrester and electrical equipment grounding has been accomplished by providing a grid of No. 4/0 stranded bare copper conductors spaced at approximately 3 ft in the immediate vicinity of the substation in addition to the use of ground rods at the substation, motors and valve operator starter racks. The grid, designed primarily for personnel protection and buried approximately 12 in. below grade level, has proved to be an excellent grounding device also, especially in western Nebraska and eastern Wyoming where ground rods alone do not provide good grounds.

In designing power and control circuits, the National Electrical Code was used as a basis of providing adequate wiring; however, in most cases, wire and conduit sizes were increased over the minimum required to provide for a better operating circuit as well as possible future increased loading. Explosion-proof raceways and equipment were provided in the areas considered hazardous. The control building and open manifold area was not placed in this category.

All circuits between switchgear, control building pump house, and out-door equipment are installed in underground conduits, which are protected with a hot application of plasticized coal tar enamel. Overhead electrical conductors are confined to the 34.5 and 69-kv utility feeder circuits in all cases.

Type TW 600-volt wire has been used for all 480, 240, and 120 volts power circuits as is the case of control wiring.

Type A V L cables were used for the 2400-volt motor circuits at the first stations to be constructed; however, neoprene jacketed 5-kv single conductor cables are being used at the other stations.

Outside the station piping area, direct burial cables are installed for tank gaging and lighting circuits requiring runs of greater distance and not subject to frequent injury while making station changes. Conduits were used where runs entered the station piping area.

The nerve center of operations has been located in a separate control building, spaced 100 to 150 ft from the pump building and electrical substation, which eliminates it as a hazardous area, with the exception of a laboratory room, which is separated entirely without openings to the remainder of the building. Explosion-proof electrical equipment is required here as all crude is tested as a matter of routine.

As all electrical equipment control is situated in the separate building well removed from the oil handling facilities, costly explosion-proof fittings and equipment are not necessary. The flow control board has been designed to include many items pertaining to the station operation. At the main line locations, the board facing an operator will present an area approximately 4 ft high and 15 ft long on which a schematic piping diagram of the station itself has been engraved on phenolic stock with valve, motorized and hand operated, check valves, pumps and motor symbols represented in their relative positions. Within the symbol itself, push button switches and equipment position lights present a station schematic layout readily interpreted by the operator for all electrically controlled equipment.

To symbolize oil operations even more clearly, lighted directional arrows indicate oil flow in main line, pump, manifold, and storage tank pipe line. The arrows are energized with the opening of valves involved in an oil movement operation.

Tank levels are read within ⅛ in. accuracy at one point on this board by remotely operated tank level transmitters.

Generally, the board contains all essential elements necessary to operate a station with electrical controls. The only exceptions are the manifold valves on oil feeder lines, which are hand operated. * * *

P 615.36

Communications System

Microwave system, 960 miles long, has four terminal and 40 relay stations

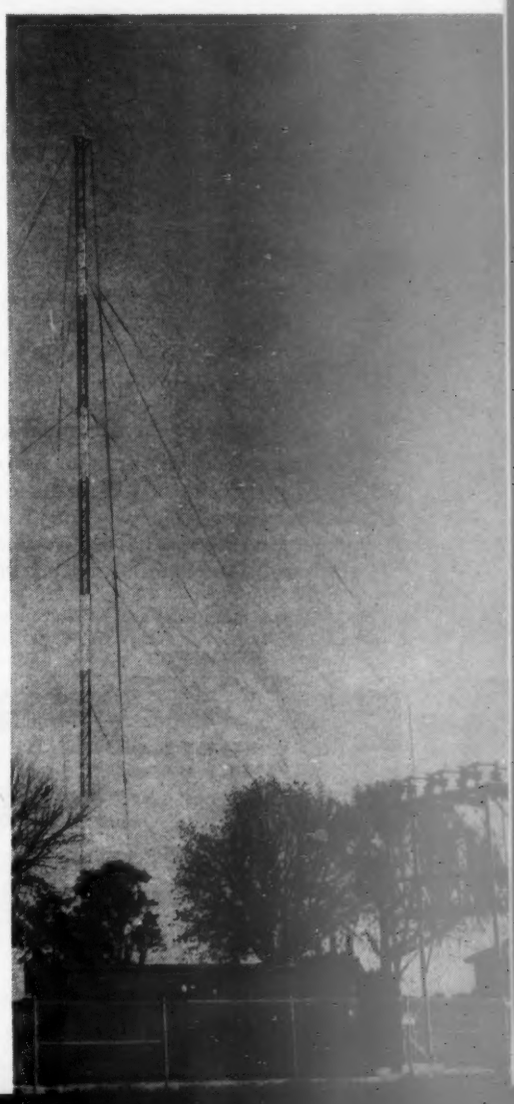
ALLEN R. HEIDEBRECHT

PLATTE's designers also maintained the modern theme in its communications system. These men of experience know that reliable communication was vital to the operations system so they took steps to insure that their communications systems would be second to none.

In the past, pipe line companies have used leased and private wire systems for point-to-point communication and more recently some have used low frequency AM radio for local dispatching.

The modern trend is toward precisely beamed microwave relay stations instead of wire lines and FM radio in the VHF bands. The microwave system can be designed to be impervious to the elements and with frequency modulation, the VHF system enjoys static-free operation. With these facts in their possession, Platte's designers commissioned a radio company to build their communications system.

The microwave relay system extending from Casper to Wood River is approximately 960 miles long. The system is composed of four terminal stations and 40 relay stations. Terminals are at Casper, Beatrice, Kansas City, and



Transformer and switchgear with microwave tower in background.

When planning your pipe line ... plan for protection

Bitumastic 70-B Enamel being machine-applied to a 20-inch gas transmission line.

PIPE-LINE engineers are proud of their completed pipe-line projects. They are the result of careful planning, expert engineering skill and plenty of hard work. And these projects deserve the best possible protection against corrosion — the protection provided by Bitumastic Enamels.

"The best possible protection against corrosion"— this claim is based on actual service records ... on *proved* performance. Many pipe lines are still carrying gas and oil underground, after more than 30 years good service. And these durable enamels have established these records under the most severe corrosive conditions.

Further, the experience gained by Koppers in safe-guarding thousands of miles of pipe lines against corrosion is available to you. Discuss your next pipe-line project with one of our representatives. He will give you complete details concerning Bitumastic Enamels.

Specify BITUMASTIC® ENAMEL

Bitumastic Enamels now available from Koppers new Fontana, California, Plant!

Koppers can now supply Bitumastic Enamels from its new plant at Fontana, California. This plant was built in order to give you better service in the west.

KOPPERS BITUMASTIC ENAMELS

REG. U.S. PAT. OFF.

KOPPERS COMPANY, INC., Tar Products Division, Dept. 1251-T, Pittsburgh 19, Pa.

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

Wood River. Casper and Beatrice are division headquarters; Kansas City is general headquarters and dispatching point, and Wood River is the line terminus. Intermediate relay stations are positioned along the line at intervals of 20 to 30 miles. These relay stations are designed for unattended operation and for the most part are in remote areas.

These automatic relay stations consist of a concrete pre-fabricated weatherproof shelter, a triangular steel guyed tower with passive reflectors, the microwave equipment itself, and an emergency power generator. Positioning of the relay station was made by selecting sites with maximum elevation, accessible roads and availability of commercial power. These foregoing requirements along with the desire of having the system parallel the pipe line for VHF purposes made considerable thought necessary in the planning.

The equipment can be described as analogous to a four-wire duplex telephone system with transmission and reception possible in both directions simultaneously. Frequency division channelizing is used to supply all the channels needed for voice communication, remote indicators, remote controls, fault locators, and for future expansion. Complete spare electronic equipment is installed in each location to provide for unbroken service in case of any failure.

With the system in operation, it will be possible for any station along the system to contact the dispatcher or any other station with no delay. Sufficient channels have been provided to take care of a number of conversations at the same time. In addition, the dispatcher can read from his console any function or fault on the system and control or supervise the system as necessary.

This instantaneous supervision over the entire system should result in tremendous savings in time and expense. Central synchronization of the various operations along the line should yield efficiency never attainable by older methods.

Initially, the two-way V.H.F. system will consist of 17 base stations and 20 mobile installations. It will be linked into the microwave system at selected points to insure coverage of the line and adjacent territory. The V.H.F. system will be used for dispatching maintenance and supervisory vehicles to points along the line and will be invaluable for re-dispatching vehicles, thus eliminating time lost in calling in by phone or traveling back to headquarters after completion of a job. V.H.F. radio will also be carried by Platte's aircraft so line breaks can be reported immediately and management can keep in touch with operations even while in flight. * * *

The first long-distance iron pipeline in the United States was a two-inch line extending five and one-half miles from the Newton Well to Titusville in Pennsylvania. The line was completed August 1, 1872 and the gas was used for domestic purposes.

Assure power for MICROWAVE systems with ONAN Standby ELECTRIC PLANTS

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to make good compressors operate better

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VOSS VALVES are made to specifications for all types of air, gas and ammonia compressors; from 1" to 16" in diameter and for pressures from minus 27HG to 7,500 pounds and for speeds up to 1,000 rpm and above.

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Don't be fooled by similarity in appearance. Be sure your replacement valves and plates are marked "VOSS" and obtain the VOSS values developed by 32 years of specialized compressor valve engineering and experience.

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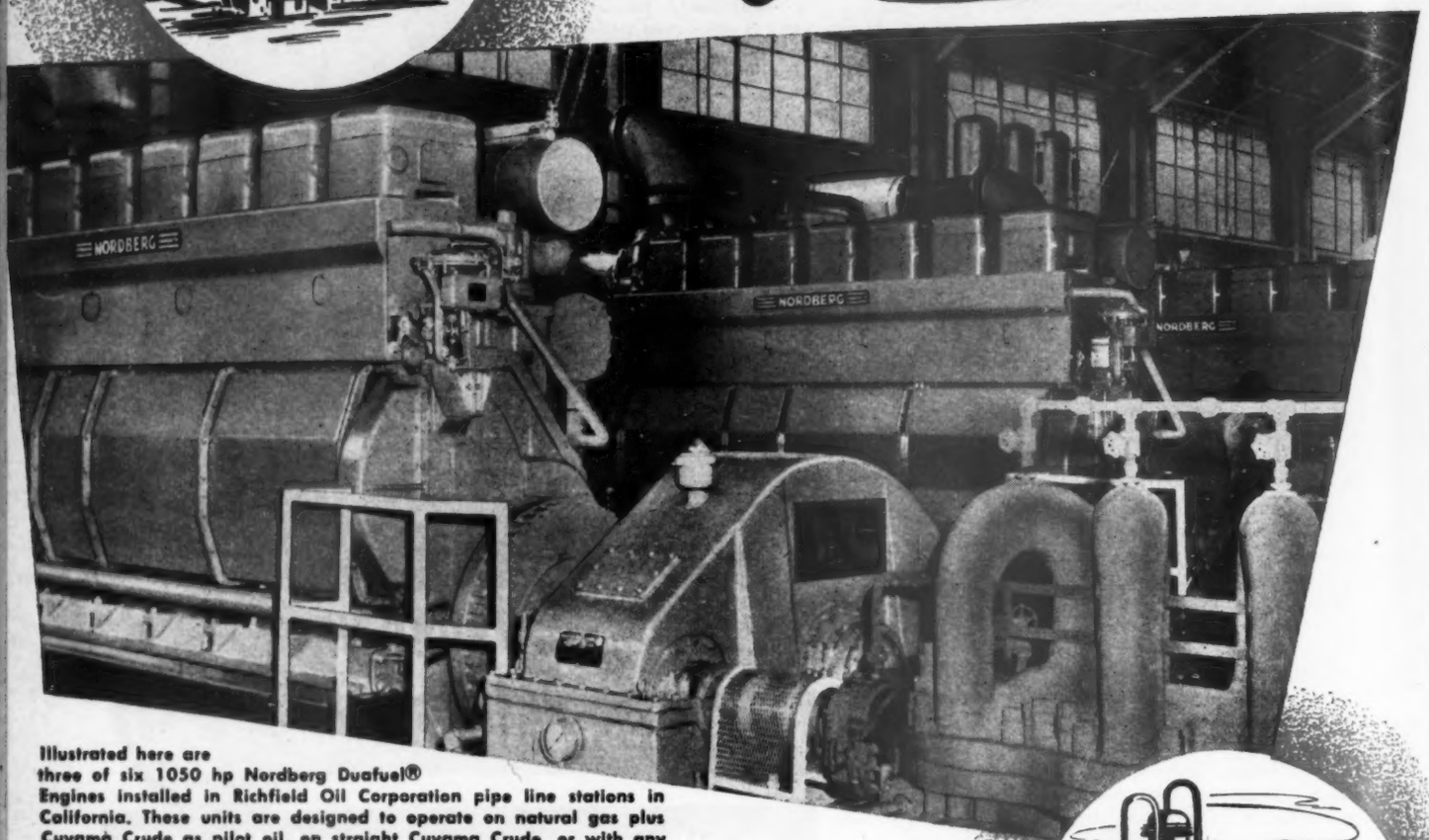
Count on NORDBERG DIESELS to keep crude and products "On the move"



Illustrated here are three of six 1050 hp Nordberg Duafuel® Engines installed in Richfield Oil Corporation pipe line stations in California. These units are designed to operate on natural gas plus Cuyama Crude as pilot oil, on straight Cuyama Crude, or with any proportion of either fuel. Instantaneous conversion from one fuel to another allows the most economical fuel to be used at all times.

FOR main line or booster stations—wherever you must keep crude and products on the move with plenty of power—you can count on Nordberg Diesels of the right size and type to do a dependable, economical job, day-in, day-out.

Scores of these rugged engines built by Nordberg and its Busch-Sulzer Division have been proved in over 25 years of pipe line service. Applications range from self-contained portable pumping units to permanent stationary installations, and generating units for station power and lighting.

Nordberg engines are available in a wide range of sizes from 10 to over 10,000 hp, including 2 and 4-cycle types, and in Diesel, Duafuel®, and Spark-Fired Gas models. *Write for further details, outlining your power requirements.*

NORDBERG MFG. CO.
Milwaukee, Wis.

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DIESEL ENGINES

Aerial view of complete compressing station installation. Southern compressing installation and building are in course of construction.

Oakford Underground Storage Project

Installation for storage of 105 billion cubic feet of gas includes many practices different from usual applications

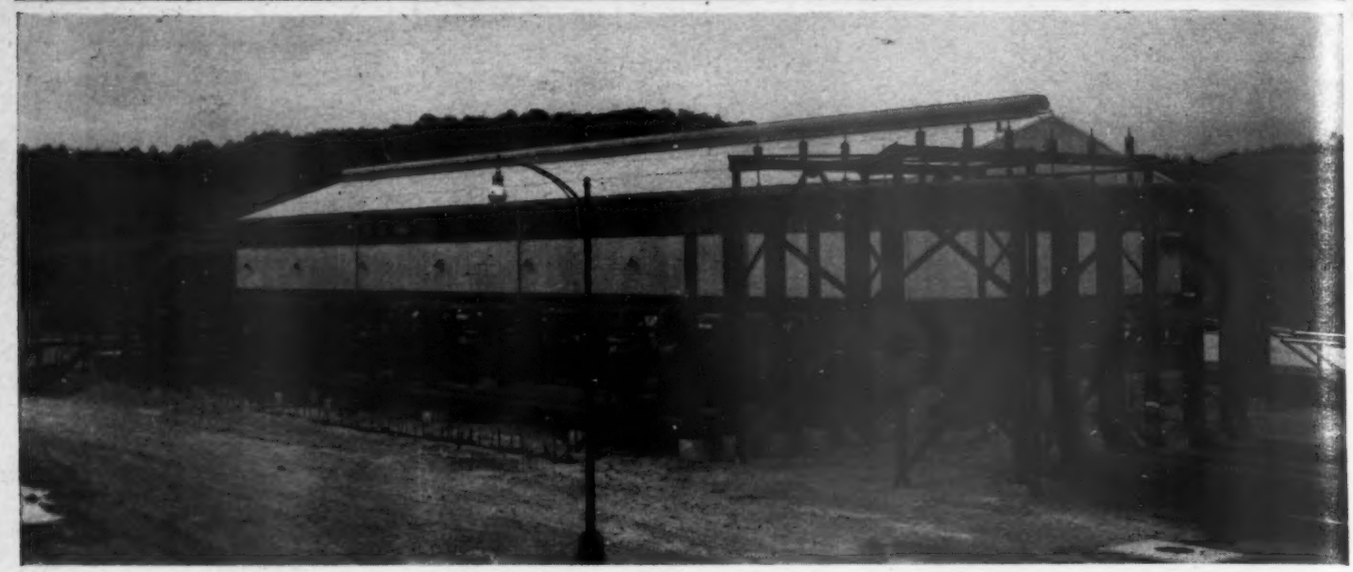
R. S. JEFFERIES

In the early development of the gas industry, distribution was in relative close proximity to production. Fluctuations in load were easily handled by controlling the required production into the pipe line. As markets for natural gas were developed and sales volumes increased, however, peak demands also increased correspondingly. Peak demands have been accentuated in the last few years due to the favorable price of gas as a fuel; and therefore, its great increase as a domestic heating medium. In the Appalachian area the increase in demand has been so large that a great proportion of the gas supply is now coming from the Southwest. This change in the source of supply of gas has made the control of supply at the source to meet demand uneconomical, due to the large size of transmission lines that would be required to meet winter peaks. Such a pipe line system would have a very poor load factor with its attendant high costs of transportation. The gas industry has been developing an alternate to this, which is the storage of gas close to the markets. The most satisfactory and least expensive storage has been the use of depleted gas-producing formations as a natural gas reservoir. One of the latest of these projects is the development jointly by New York State Natural Gas Corporation and Texas Eastern Transmission Corporation of the Oakford storage area.

EXCLUSIVE

The Oakford storage area is in Westmoreland County, Pennsylvania, in the southwestern portion of the state. It is situated geologically in the north central portion of the Appalachian Basin along the eastern flank of development on the Grapeville Anticline. There were several productive sands in this area, but the two principal producing sands were the Murrysville and Fifth sands, which are being developed for this storage project.

The Murrysville is the shallower of the two sands, being 1400 ft below the surface. It is about 100 ft in thickness with an average pay depth of approximately 50 ft. The gas accumulation in the Murrysville sand was due to structure. Gas accumulated in the top of the



View of northern compressing building, main header and expansion bends, valving and piping connections to the engines.

dome limited along the axis of the anticline by saddles on each end. The low portion of the structure is effectively sealed by salt water. This sand is very coarse and pebbly and has a porosity of about 20 per cent.

The Fifth sand is an average 2200 ft below surface. It is about 60 ft thick, and has 20 ft of productive sand with an average porosity of 13 per cent. The trap in the Fifth sand is due to porosity being sealed on its boundary by tight-sand. The large number of wells drilled in this area have established the boundaries of both pools.

The Oakford area is one of the oldest gas-producing districts in the country. The development of gas production as an enterprise separate from oil began about 1885 near Murrysville, Pennsylvania, which is a few miles west of Oakford. Large gas wells were found in what was called the Murrysville sand in the search for oil. The first wells were drilled in the Murrysville sand in Oakford in 1887. Exact information is lacking but from information that is available, the rock pressure was 600 psi plus, and well flows ranged from 10,000,000 to 40,000,000 cu ft a day. Fifth sand production was discovered in 1907 and had an initial rock pressure of 1100 psi with well open flows of from 20,000,000 to 30,000,000 cu ft a day.

The plans are to operate the Murrysville sand at a top inventory of 85 billion cubic feet of gas, and the Fifth sand at a top inventory of 20 billion cubic feet of gas.

The Oakford area as a storage project is not new. North Oakford was one of the earliest storage projects, and was first used for storage by the Peoples Natural Gas Company in May, 1937; 2.4 billion cubic feet of gas were stored through 1937 and 1938. This gas was later withdrawn with no loss. Due to the large size of the pool, the gas stored increased the pressure very little—being from 8 to 22 psi gage. This early experience indicated the value of this storage area for its present development.

After the wells are located, it is necessary to recondition them for their intended use in the storage project. Some wells are plugged and others are refitted for service as storage wells. Years ago, when many of the old wells were abandoned, tools for cutting casing for removal were not available. Consequently, it was the practice to "shoot off" this casing and remove as much as possible. If after the first shot deep in the hole the casing was still tight, a second shot was placed higher in the hole and an attempt made to remove a shorter string of pipe. This old practice has been one thing that has made reconditioning the wells very difficult. Many hard-fishing jobs have been encountered to remove old pipe battered in this manner. Old cable and tools have also been found in some of the wells. Due to the age of the field, much of the pipe in the wells is badly corroded. In some cases the corrosion is so complete that the pipe had to be fished for repeatedly, as it could not be removed in a continuous string. In some cases where a plugged well was reworked, the original plugging job on the well was found to be poor and a replug was advisable. Due to this, it has been necessary to redrill all wells and put them into acceptable shape for the storage project. After each well is drilled out, a gamma ray log is made of the well to check the depth of the various formations against the drilling log.

A study of the pool was made and a pattern of wells retained to uniformly blanket the productive area. All wells not required were cleaned out and plugged. The required wells were cleaned, new casing run, cemented, and new christmas trees and wellhead piping installed for 1500-psi test pressure. The wellhead is connected immediately into a drip and thence to an orifice meter run. Six-inch laterals are run from the meter run to the trunk line connection. The flow from the lateral is passed through a second drip before entering the main line. The main trunk line through the pool is 20-in. pipe with secondary lines of 8-, 10-, 12-, and 14-in. pipe, depending on their location.

It is anticipated that the two pools will have a total storage capacity of 105 billion cubic feet of gas. Approximately 60 billion cubic feet of the gas will be cycled each year to supply peak demands.

The compressor station design pressures for flowing conditions to and from the pool are as follows:

Minimum pressure to the station from the transmission lines—450 psi.

Maximum discharge to the lines—850 psi.

Minimum pool pressure — 150 psi Murrysville sand, 400 psi Fifth sand.

Maximum discharge to pool—600 psi Murrysville sand, 1200 psi Fifth sand.

Maximum flow to or from storage—400,000,000 cu ft a day.

The Fifth sand will hold about 20 billion cubic feet when filled, and the Murrysville sand about 85 billion cubic feet. The Fifth sand being the small high-pressure pool, it is desirable to hold the inventory at near to maximum so that a high delivery will be available for peak demands. Considering these factors, the station is designed to handle 400,000,-

The Author

Robert S. Jefferies is chief mechanical engineer and superintendent of compressor stations for the New York State Natural Gas Corporation. He was graduated as a mechanical engineer from Case Institute of Technology in 1938. After graduation he was employed by the Peoples Natural Gas Company as a junior engineer. In 1945 he became assistant chief mechanical engineer of the company he now represents, and was promoted to his present post in September, 1951.

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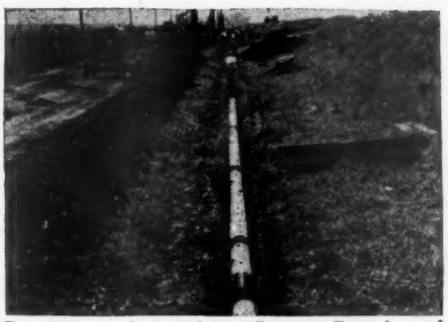
TRANTEX *polyvinyl* TAPE

. . . a cold applied wrap that protects underground and overhead oil and gas lines from corrosion



Tough, corrosion-resistant Trantex Tape is used here to repair holidays in the line. Easily applied, it is an economical material for this service.

For the field joints of this transmission line, Trantex Tape is used to give these critical spots lasting protection against corrosion.

FOR more than fifty years Johns-Manville has been manufacturing pipeline protection material. This experience, plus the knowledge gained in the research laboratory and in the field about the effects of corrosion, have gone into the making of "Trantex"—a new plastic tape for extending the service life of oil and gas lines.

Trantex needs no special equipment in its application. It is easily applied by hand or hand-operated devices. A pressure-sensitive adhesive forms a tight bond with the pipe—shields it against the general corrosive conditions that cause most pipeline failures. Trantex has proved remarkably resistant to the effects of soil chemicals, acids, alkalies, alcohols, oil and grease, sunlight and aging.

Check the basic properties of Trantex in the table below—each one is extremely important in the control of corrosion.

For more detailed information about Trantex *polyvinyl* Tape, write to Johns-Manville, Box 60, New York 16, N. Y.; in Canada, 199 Bay Street, Toronto 1, Ont.

	*V-10	**V-20
Dielectric Strength per mil thickness, Approx.	1,000 V	1,000 V
Insulation Resistance, greater than (ASTM-D-257-49)	100,000 megohms	100,000 megohms
Operating Temperature	200 F	200 F
Adhesion	30 oz per inch	20 oz per inch
Tensile Strength	30 lbs per inch	56 lbs per inch
Elongation at Break	250%	300%

"Trantex" is a black polyvinyl tape. It is available in two thicknesses—
*V-10 is a 10 mil tape for general conditions, and
**V-20 is a 20 mil thickness for use where a more rugged coating is specified.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville TRANTEX *polyvinyl* TAPE

PROTECTS PIPELINES AGAINST CORROSION

High pressure piping and valves, dust scrubbers, mist extractors, southern compressor building and installation in course of construction.

000 cu ft a day of gas either to or from storage. The maximum design pressure is 1500 psi, with 30,000 installed horsepower.

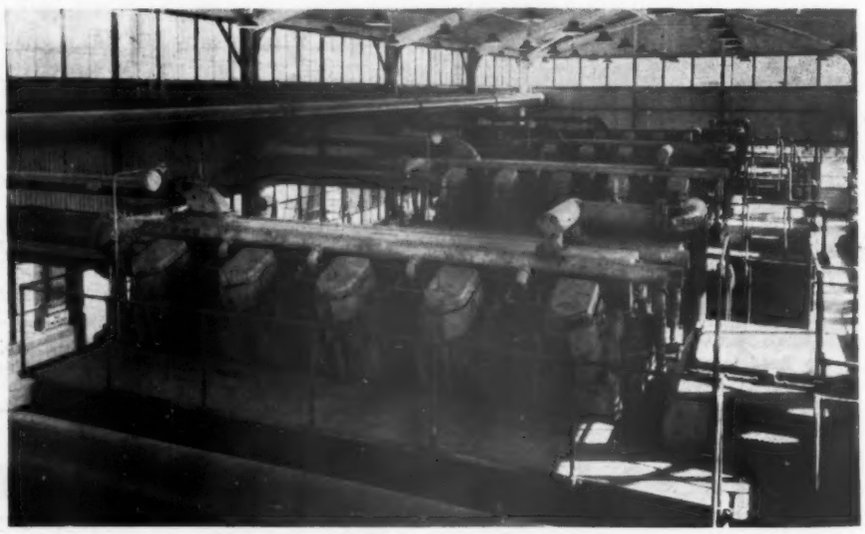
There are two transmission lines and three storage lines that terminate at the station site with motor-operated fire gates. These lines then connect to four groups of 12-in. meter runs; one group each for the Texas Eastern line, New York State line, the Fifth sand pool line, and two Murrysville sand lines. The meter runs are reversible so that flow can be measured in either direction by merely changing the instrument lines through valving at the orifice fitting.

It is required that gas be taken from any source (either pipe line or pool) and delivered to anyone or all three of the other lines. Accordingly, the piping is quite complicated. There are two complete header systems so that gas can be compressed at two different pressure conditions. Also, if necessary, it is possible to compress the gas through two stages of compression. Each engine is connected so that it can operate on either piping system.

The installations are situated on three elevations. Dehydration and metering equipment are on the first elevation. On the second elevation are the two compressor buildings—the main gas piping, and gas scrubbing and cooling elements. The lower level contains the office and personnel building, the auxiliary building, and the shop and warehouse building.

The compressor installation was divided into two units of 15,000 hp each, so that the possibility of losing the whole installation in case of piping or equipment failure would be decreased. One compressor building is situated at each end of the station site with the scrubbing and cooling units placed centrally

Auxiliary 1000 kw generating equipment and switchgear.



Interior view of initial compressor building.

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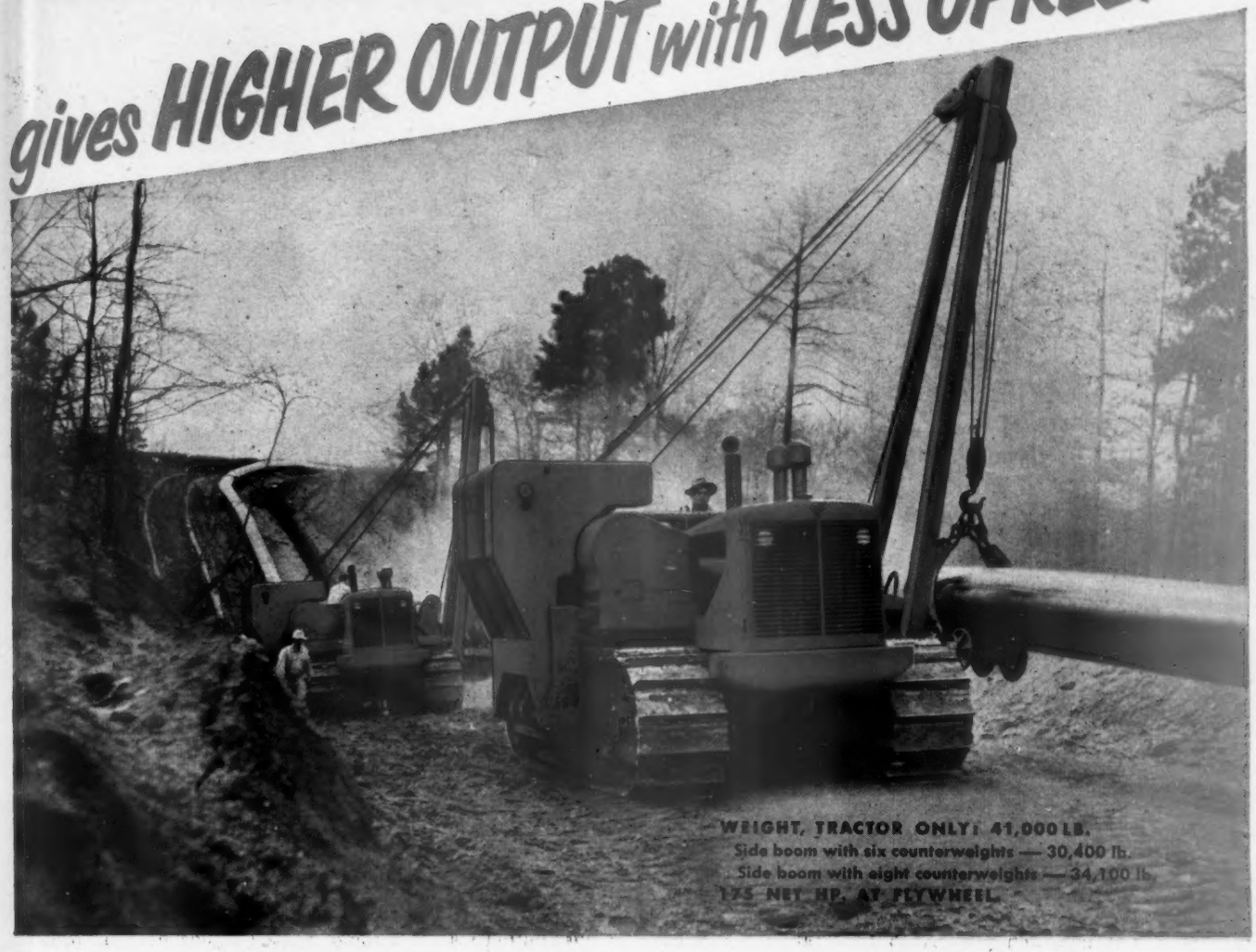
WEIGHT, TRACTOR ONLY: 41,000 LB.
Side boom with six counterweights — 30,400 lb.
Side boom with eight counterweights — 34,100 lb.
175 NET HP. AT FLYWHEEL.

Exclusive Hydraulic Torque Converter Drive is One BIG reason why

The hydraulic torque converter drive, exclusive in the Allis-Chalmers HD-20 Tractor, brings you productivity, handling ease and dependability that makes every hour, every day of the season count . . . gives the operator the equivalent of hundreds of gear ratios in two speed ranges . . . automatically selects the proper speed for maximum production.

LAND CLEARING — With hydraulic torque converter drive you take full advantage of available horsepower . . . you'll roll bigger loads, tackle tougher dozing jobs. Master clutch engages under cushioned protection, yet power is achieved instantly with velvet-like smoothness. This means fewer repairs . . . longer life of tractor and auxiliary equipment.

PIPE LAYING — With shifting virtually eliminated, operator can concentrate on side boom work and control signals. Liquid-smooth, cushioned power assures smooth lifting and cradling of pipe — no jerking or jarring. Torque converter drive permits operator to throttle way down so that tractor can creep along over soft going without skidding or digging in — a big advantage in handling pipe, moving other equipment.

PULLING AND PUSHING — There's nothing like the HD-20 for sheer productive power. Torque converter actually multiplies torque up to four and one-half times . . . developes tremendous drawbar pull to start heavy bending machines and haul or push pipe trucks smoothly, easily. With torque converter drive, operator quickly synchronizes tractor's speed with equipment being pulled or pushed — an important advantage when working with cleaning and priming or doping and wrapping machines.

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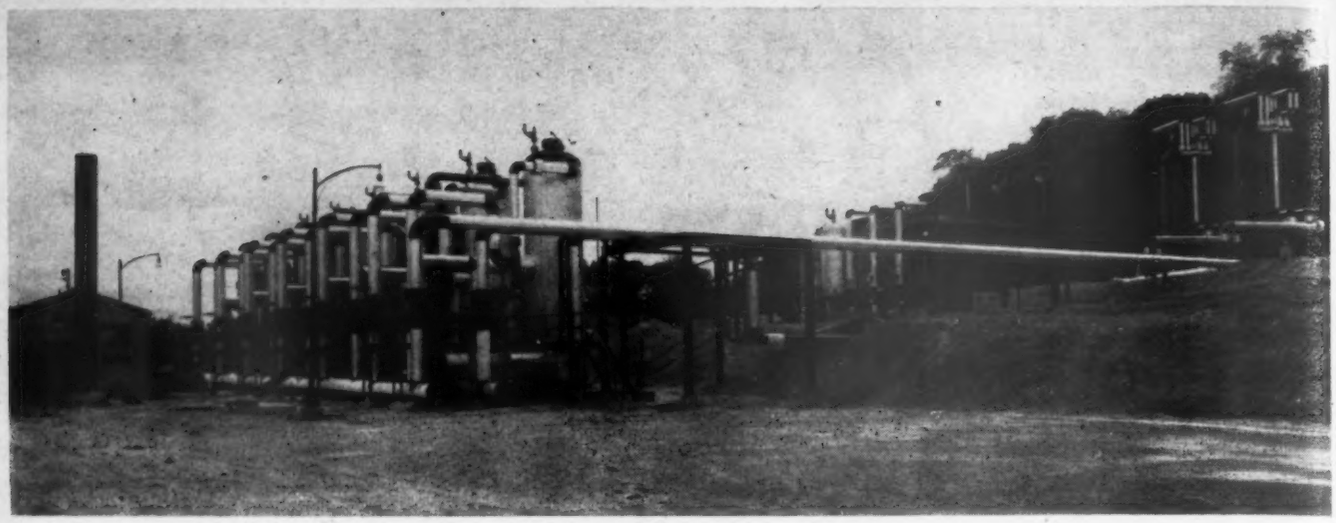


Dehydration plant showing electrical control and meter building, absorbers and piping, regeneration cooler, accumulator and compressor building, and regeneration heaters.

between them. Six 2500-hp Cooper-Bessemer GMW units are installed in each building. The compressors are 13¾-in. in diameter and are sized at a suction pressure of 150-psi gage and a discharge pressure of 1200-psi gage. These pressure conditions will take care of the gas at minimum conditions. The compressor cylinders are equipped with valve lifters so that the cylinder displacement can be regulated to load the engines at varying pressure conditions as gas is injected or withdrawn from storage. The valves controlling the gas to and from each engine compressor unit are pneumatically controlled by a panel at the end of each engine containing the controls for these valves. Fluor pulsation dampeners are used on the compressor discharge. The pulsation problem is a particularly difficult one, due to the wide range of compressor arrangements obtained with the valve lifters, the suction pressure range from 150-850 psi, and the variation in engine speed required in balancing flow against demands.

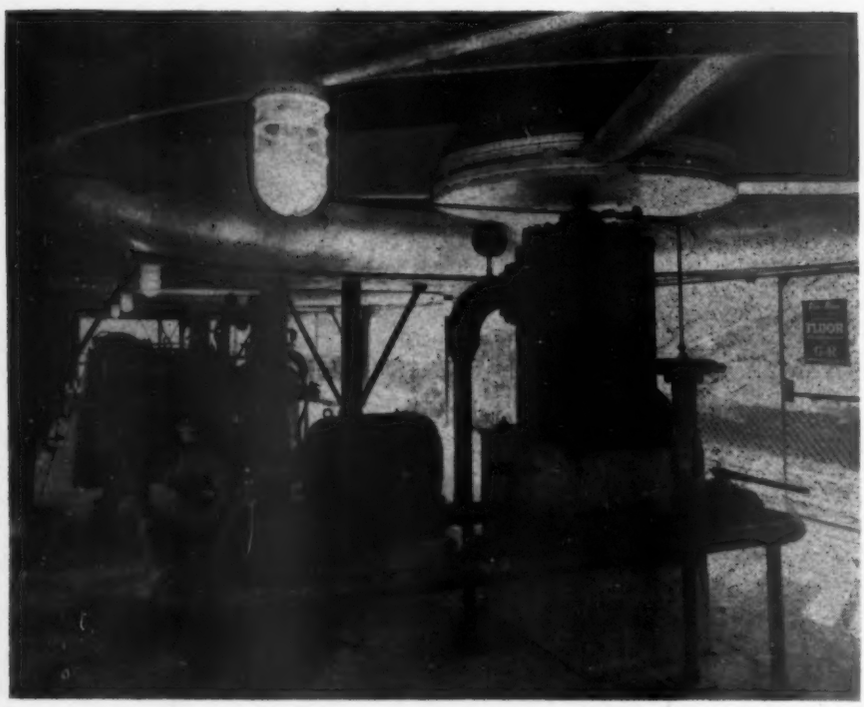
Practically all valves on the station are motor-operated. This is necessary because of the large size of the valves and the amount of labor and time required to operate them by hand. (Average time —30 min.) In the end of the compressor building is a control panel that operates all gas valves at the cooling sections, which are connected to the discharge and suction lines for that unit. The controls are electrical push buttons, which activate pneumatic motors. Indicator lights at each push-button station show the position of that valve. A piping diagram sketch between push-button stations indicates the relative position of each valve in the piping system. The arrangement of the second compressor building is similar to that of the first.

The water supply at the plant site is limited so it was necessary to design the major portion of the cooling for air cooling rather than evaporative cooling.

The hot discharge gas is cooled by a battery of 20 fin tube sections designed for 1500-psi gas working pressure. Air is circulated through the cooler by five propellor-type fans that operate at constant speed. During cold weather gas temperatures must be watched closely, due to the possibility of hydrates forming in the cooling sections if the gas becomes too cold.

The hot jacket water is cooled in 20 fin tube sections. Air is circulated through these sections by four propellor-type fans that operate at variable speed to maintain a constant jacket water temperature to the engines. The fan drive is a Rockwell "Rotocycle" hydraulic motor and pump unit. The pump circulates a constant volume of oil to the motor. Variable speed is obtained by connecting a temperature controlled regulating valve in parallel with the hydraulic motor so that the amount of oil driving the motor may be varied by the amount being bypassed. As the temperature of the water increases, the regulator valve closes, forcing more oil through the motor and increasing fan speed. This arrangement so far has been satisfactory in its control of jacket water temperature.

In a storage project, the winter station operation is generally intermittent and the load is quite variable. Due to these conditions, air cooling of the jacket water is not desirable because there is always the problem of regulating cooling and seeking to avoid freezing during winter weather. It is not feasible to charge a cooling system of large size with anti-freeze, due to the cost involved and the difficulty of disposing of waste water. To overcome this difficulty, the variable-speed fans were specified and each cooling section is valved so that it can be excluded from the system and drained. This enables the operators to



Rockwell "Rotocycle" hydraulic drive mechanism and piping for controlling fan speed on hot jacket water cooling system.

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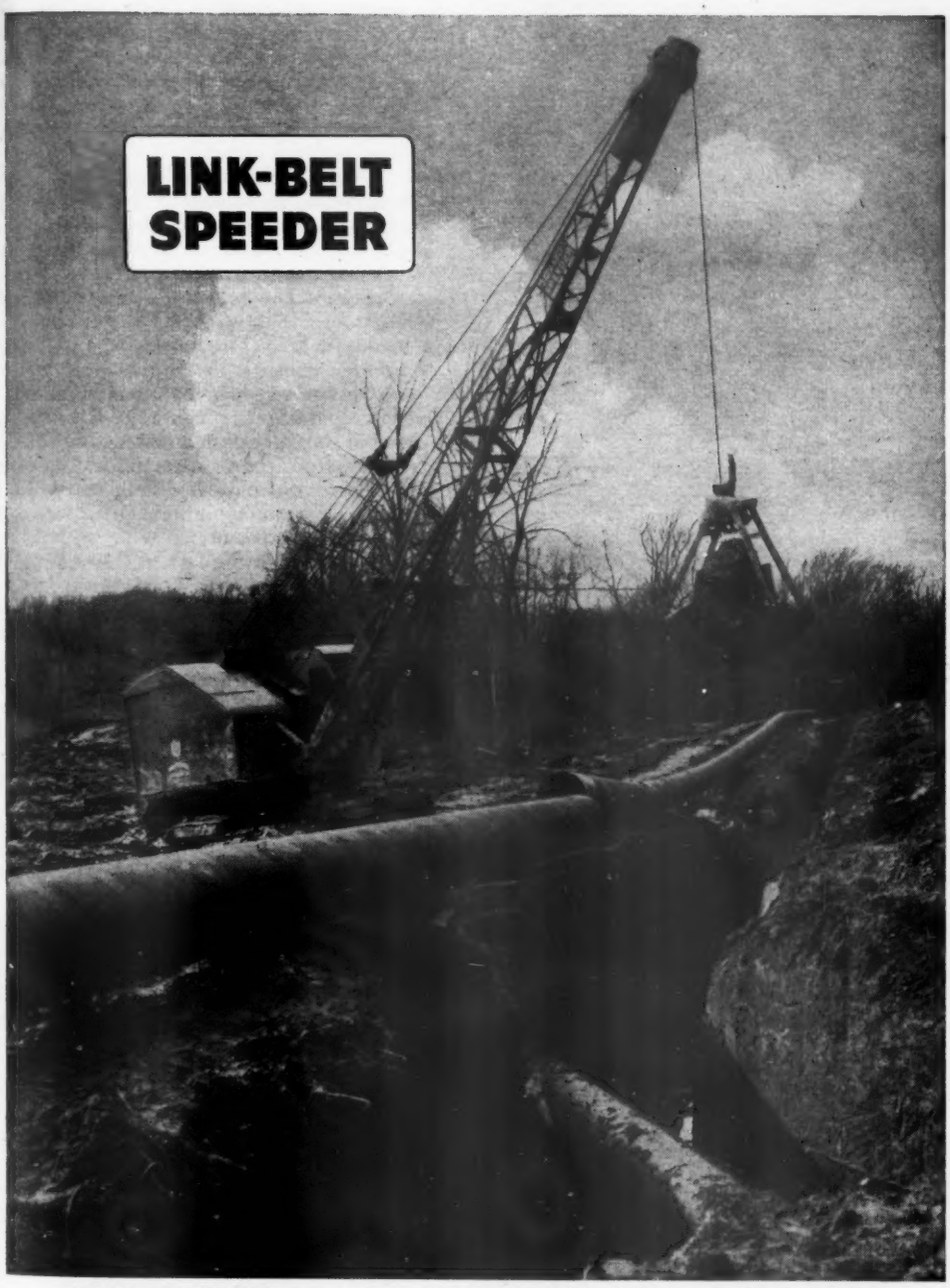
LS-85 licks the pipeliner's toughest problems



MORRISON CONSTR. CO., Austin, Texas, depends on the heavy-duty ¾ yard LS-85. This brute is popular because boom changes can be made quickly in the field . . . sturdiness prevents down-time . . . and the LS-85 has the power pipeliners demand (its diesel engine delivers 92 net h.p. at full load speed).

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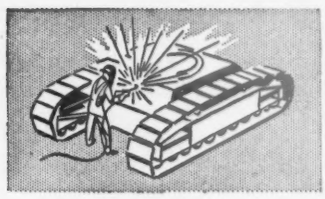

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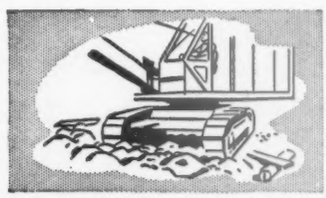

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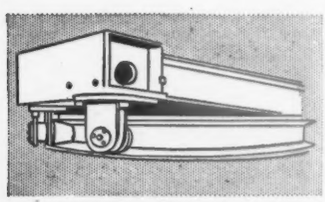

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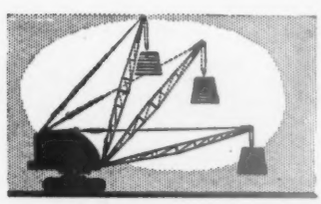

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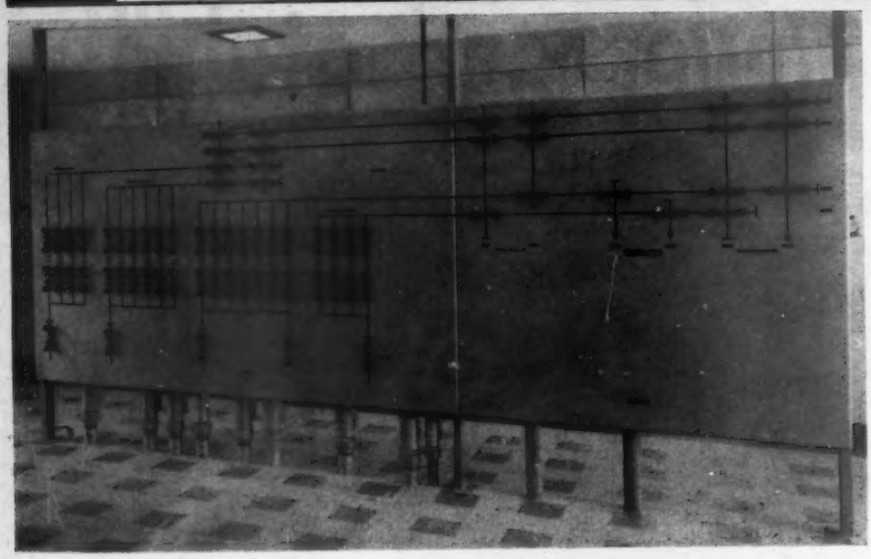
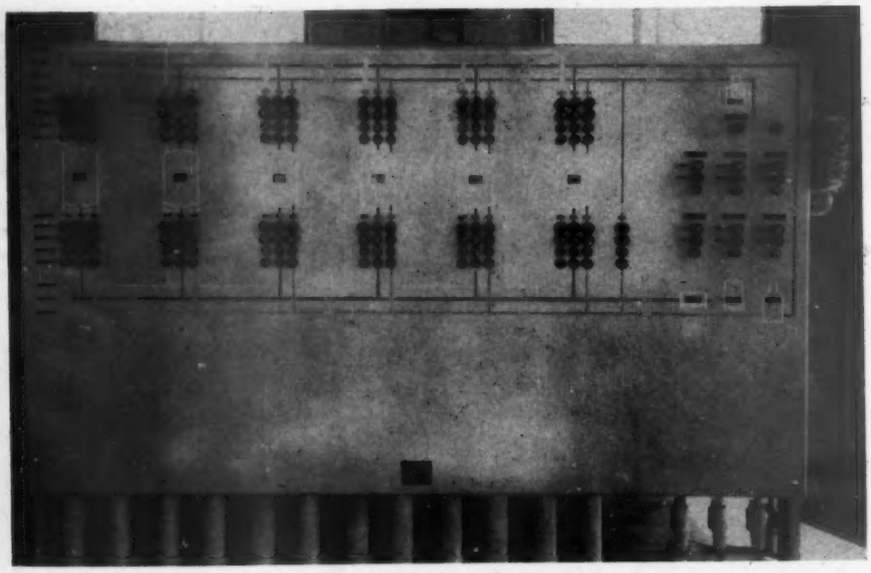
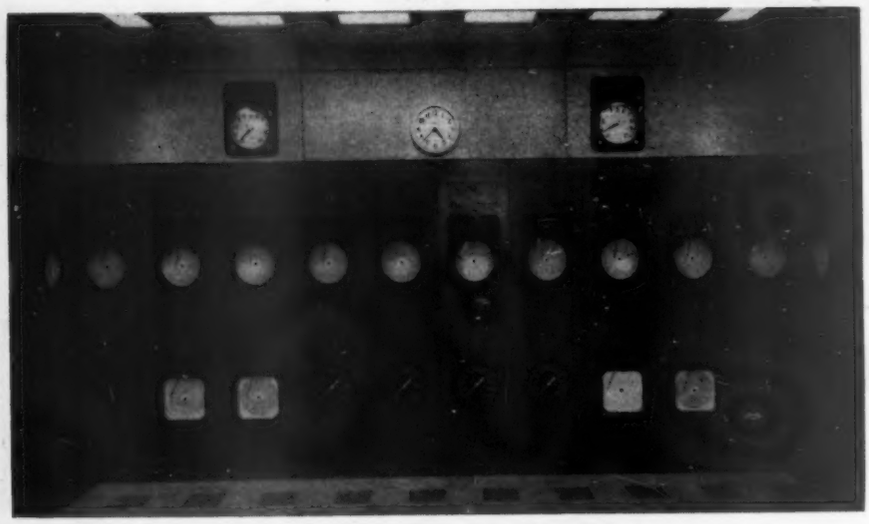


Main push button control panel in the meter building showing indicating lights and pushbuttons on flow diagram of meters and main header connections.



Dehydration plant electrical control panel.



Main gage and meter panel board in meter and control building.

regulate the cooling surface to the demand. Two of the four cells are equipped with louvers over the top of the radiators to afford further control for light loads.

The cold jacket water system for compressor jacket and oil cooling utilizes bent tube sections mounted in the base of an induced draft cooling tower. Water temperatures of 110 F are required for this system. The direct air coolers for an approach this close to atmospheric temperatures are expensive. As sufficient water is available for evaporative cooling, the cooling tower was selected as the most economical and best solution to this problem.

Good cooling water with a low concentration of minerals is essential in closed cooling systems. To insure a supply of soft water, a large cistern was constructed into which all roof drains were run. The rain water thus collected is stored in two 200,000-gal storage tanks. It is necessary to treat the inside of the cistern with a water-proof coating as the water picks up calcium compounds from the concrete. It is also found that a certain amount of hardness comes from the transite roofs. The soft water in the closed systems is treated with chromate to inhibit corrosion and retard scale formation.

Power for the plant is obtained from three 1440-hp Worthington supercharged engines driving 1000-kw. Ideal 3-phase alternating current generators. When the complete plant is operating, two of these units will be required and the third will be a spare. The power distribution panel is of the totally enclosed dead front type. It is a low-voltage, metal-enclosed, draw-out-type switchgear constructed by the Ideal Electric Company. Electrical circuits through the plant are all in underground conduit with concrete junction and pull boxes situated as required.

Heat is supplied to the plant by two Babcock and Wilcox packaged integral furnace boilers, each with a capacity of 14,100 lb of steam per hour at 100-psi pressure. The boilers are equipped with a complete automatic control and safety system.

The nerve center of the installation is the meter and control building. The outside telephones terminate in this building so that all operating instructions will be directed to the station dispatcher. Inter-plant phones are connected from here to the compressor buildings, the auxiliary building, and the office. The plant dispatcher has a complete and quick picture of the plant's operation as the orifice meter instruments, pressure, and temperature recorders, and pressure gages for the various meter runs and pipe lines are mounted on a U-shaped panel board in front of the operator. Behind the main panel board is mounted air-actuated totalizing equipment on an auxiliary panel board. These transmit an indication of the total flow on an instrument mounted above each group of meters representing the flow into a line or pool. A panel board behind the operator contains push-button valve operators with indicating lights for operating the meter run valves and the main plant

header valves in the immediate area. One meter run in each group is equipped with inching equipment, so that the operator can control flow by pinching the valve when it is desirable to do so.

As the gas coming from the storage pools is wet, it is necessary to dehydrate it before it is pumped into the transmission lines. Gas from the compressors is cooled and then passed through mist extractors, which remove any entrained liquid, before going to the dehydration plant. The dehydration plant is of the dry desiccant type using "Sovabead" for the desiccant. The operating cycle is conventional with two exceptions. Normally, regeneration gas drive is obtained by creating a differential pressure on the main stream of gas sufficient for regeneration gas circulation; however, it was found that there was a considerable waste in horsepower if a differential pressure was held on the total stream of gas. Accordingly, a small 110-hp Ingersoll-Rand engine is used to circulate regeneration gas. This also has the additional advantage that if flow from storage is discontinued while some of the beds are wet, it is possible to circulate regeneration gas with no flow through the plant. Secondly, the plant is designed for continuous automatic operation. A robot control changes the valving automatically so that every two hours a wet absorber is taken off for regeneration. This absorber is heated for two hours and at the next change of the cycle changes to a two-hour cooling period, after which it goes back on the line. With this operation, therefore, the heating and cooling equipment is operating under continuous load instead of intermittent load, as in a conventional plant. The towers also are unconventional in that the gas passes from the top and bottom inlets to a center outlet connection. The desiccant bed is supported at the bottom only. Gas leaves through a perforated annular ring at the center of the bed. In this system there is no chance for the bed to lift with consequent dusting and breaking of the desiccant.

Safety precautions have been taken in that a plant shut-down switch is placed at each end of both compressor buildings, at the meter building, and at the auxiliary building. In case of emergency, the total plant can be shut down and the fire gates closed by pressing one of these switches. Separate emergency air tanks near the fire gates contain enough compressed air to operate all fire gates with no additional supply.

At the present time, the installation has been partially operating for about eight months. The inventories of the storage pools are still quite low considering the final inventories when the pools are full. Accordingly, operating experience will be obtained as final storage conditions develop.

Geological information was obtained from an unpublished report by F. H. Finn, R. J. Murdy, and S. S. Galpin. Drilling and field information was obtained from E. C. Inghram. * * *

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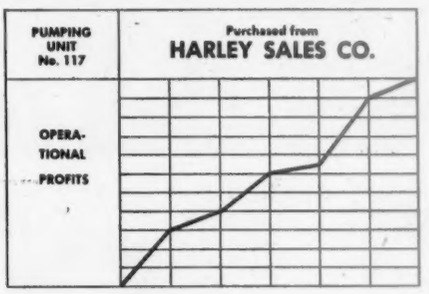

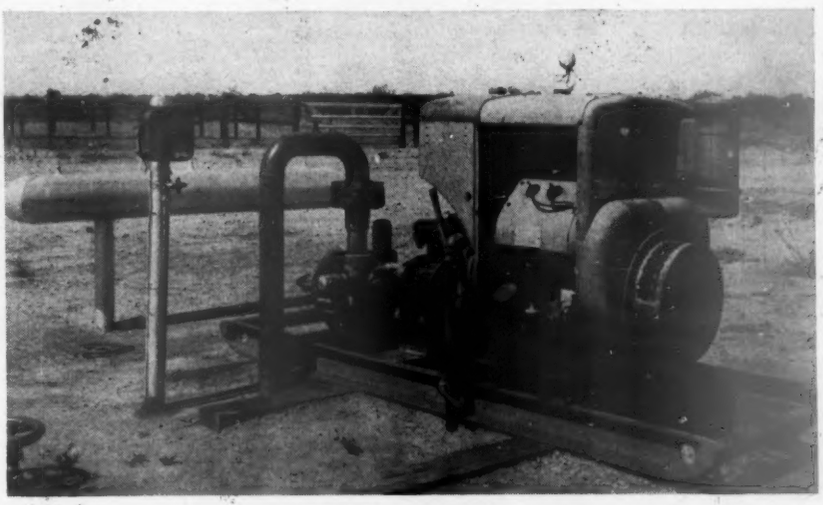

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Pictorial

Pipeliners at the API meeting in Chicago —

1. R. G. Strong, Natural Gas Pipeline of America; Mike Nelson and B. D. Leuty, Cities Service Pipe Line Company.

2. A. L. Christy, Pure Oil Company; R. P. Hamilton, Southeastern Pipe Line Company, and Dean Glass, Pure Oil Company.

3. J. G. Norton, Magnolia Pipe Line Company; H. H. Anderson, Trans Mountain Oil Pipe Line Company, and C. D. Bailey, John Inglis Company, Ltd.

4. George F. Brigance, Socony-Vacuum; C. Hobson Dunn and J. Dub Arthur, Eastern Pipe Line Contractors, and J. B. Hickey, Socony-Vacuum.

5. R. J. Tibbetts and W. H. Morris of Sinclair Pipe Line Company.

6. V. J. Sittle and C. W. Butler, Service Pipe Line Company.

7. J. L. Seger and W. F. Davis, Interstate Oil Pipe Line Company.

8. H. E. Crane, Koppers Company, and A. N. Horne, Trans Northern Pipe Line Company.

9. Glenn L. Ladd, Sinclair Pipe Line Company, and Morgan Martin, Gulf Refining Company, pipe line department.

10. R. L. Henry, Pipe Line Service Company, and B. H. Means, Pittsburgh Coke & Chemical Company.

11. D. H. Lewis, Shell Pipe Line Corporation; E. W. Jacobsen, Gulf Research & Development Company, and Louis M. Miller, Sun Pipe Line Company.

12. L. S. Wrightsman, Humble Pipe Line Company, and O. D. Stallard, Magnolia Pipe Line Company.

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Pictorial

API Pipeliners at Chicago

13. J. H. Tubbs, Deep Rock Oil Corporation; R. C. Nicholson and Don F. Sears, Shell Pipe Line Corporation, and M. E. Grant, Plantation Pipe Line.

14. J. W. Emison and R. B. McLaughlin, The Texas Pipe Line Company, and A. E. Pecore, Humble Pipe Line Company.

15. J. R. Mills, Jr., and A. H. Newberg, Service Pipe Line Company; J. R. Shipley, and Ralph Jackson, Sohio Pipe Line Company.

16. J. H. Robinson, Union Oil Company; R. K. Paine, Standard of California, and G. H. Supple, General Petroleum Corporation.

17. W. W. Baker, W. H. Morris, and W. B. Blanchard, all of Sinclair.

18. All of Plantation Pipe Line: Charles R. Younts, W. K. Borland, S. V. Kane, W. G. Horstman, and M. J. Dabney.

19. L. R. Dickinson, Socony-Vacuum; J. Dub Arthur, Eastern Pipe Line Contractors; L. H. True, Magnolia Pipe Line Company, and Richard A. Gump, Pipe Line Contractors Association.

20. J. E. B. Gibbons, Koppers Company; Ralph Miller, Nordberg Manufacturing Company, and O. Q. Lomax, Humble Pipe Line Company.

21. Glenn Ladd, Sinclair Pipe Line, and Ralph F. Moore, Platte Pipe Line Company.

22. B. Brewster Jennings, Socony-Vacuum Oil Company, and Vice Admiral W. M. Callaghan, Military Sea Transportation Service.

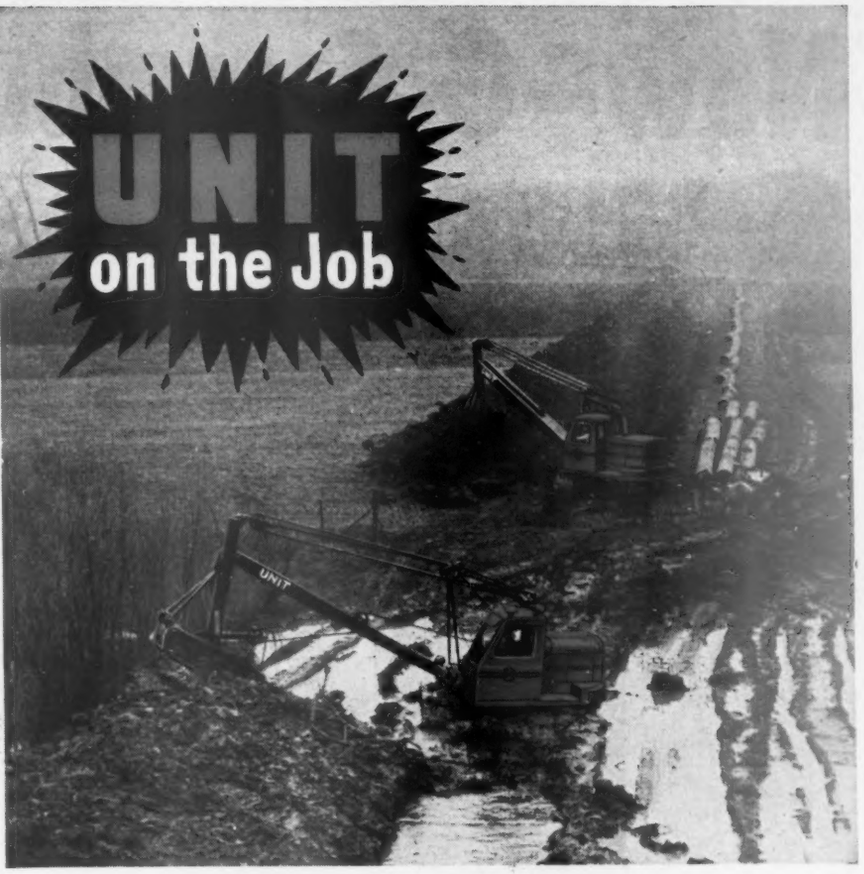
23. P. C. Spencer, Sinclair Oil Corporation.

24. T. R. Aude, Service Pipe Line Company; Tom L. Holcombe, Holcombe & Stearns, and L. R. Dickinson, Socony-Vacuum Oil Company.

25. O. C. Mudd, Shell Pipe Line Corporation, and M. J. Dabney, Plantation Pipe Line Company.

26. R. H. Lynch, Keystone Pipe Line Company, and Herbert E. Fisher, C-R-C Engineering Company.

27. A. N. Horne, Trans Northern Pipe Line Company; H. C. Price, H. C. Price Co., and H. C. Price, Jr.



Pair of Pipe Line Profitmakers!

Here are two UNIT TRENCHOES speeding up the ditching operation on a cross country pipe line project. This type of operation is familiar to pipeline contractors because they know, when the going gets tough, it takes a rugged machine to do the job efficiently. UNIT TRENCHOE is this type of machine. Its fast operating speed is a real time and money saver on pipe line work. UNIT'S exclusive mechanical features, together with the streamlined FULL VISION CAB, make UNIT a front line machine in the pipe line construction field.

Then there are Mobile UNITS for jobs along the right-of-way. Mobile equipment offers road travel speed, plus sufficient traction to operate in rugged pipe line terrain.

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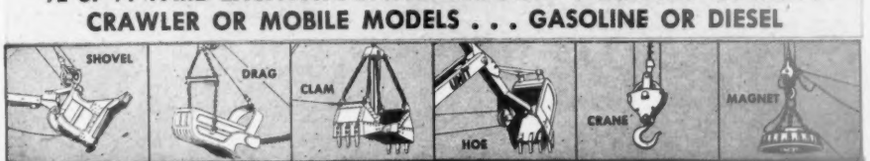

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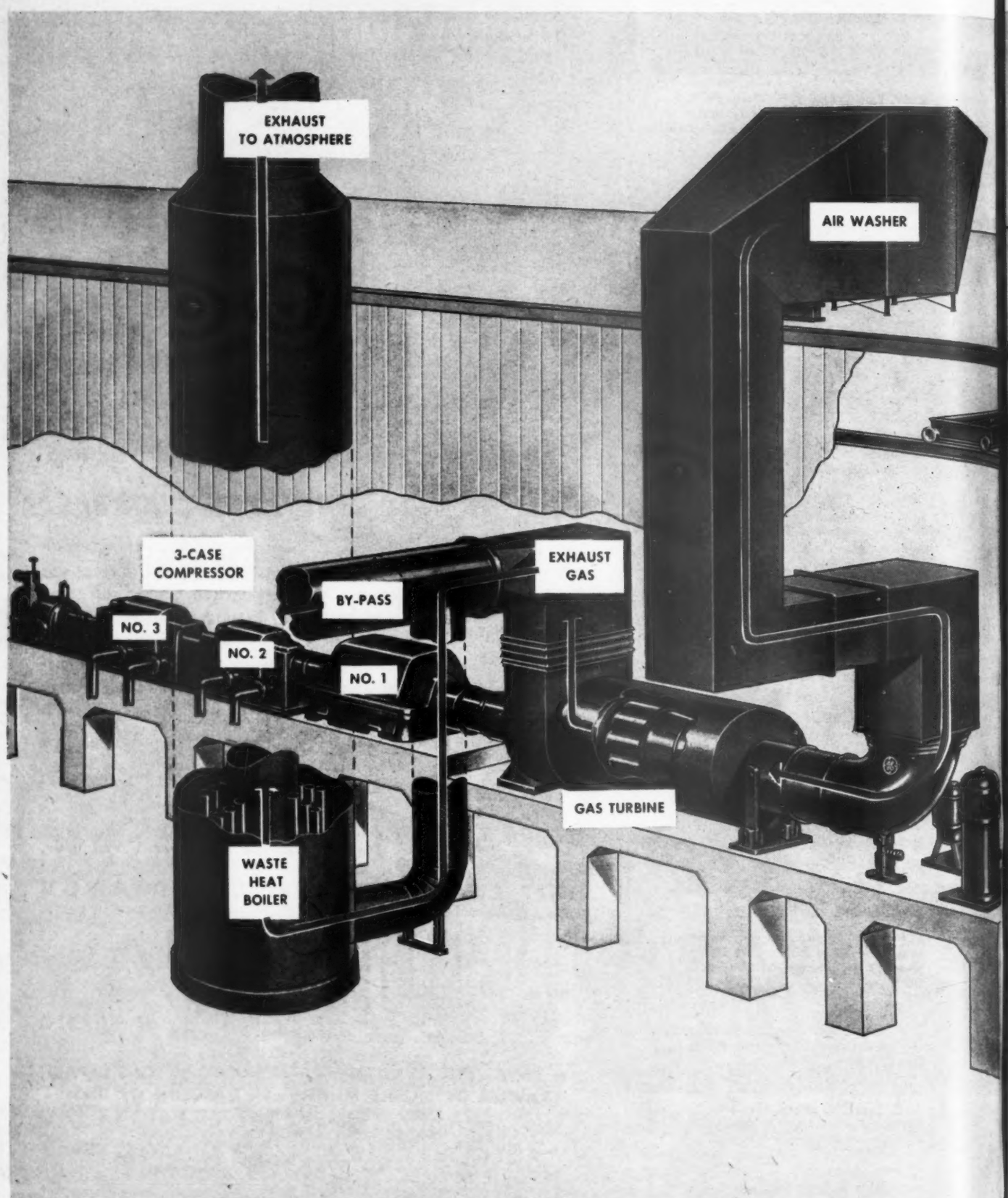
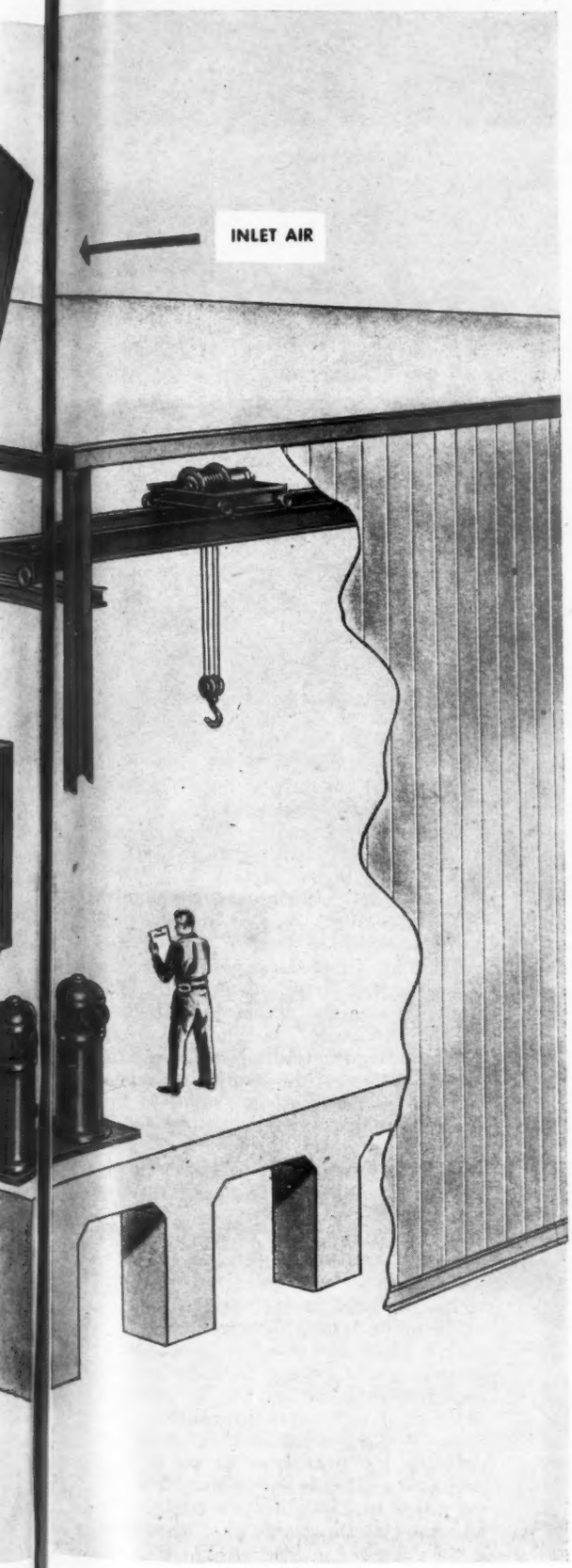
Now—G-E combustion gas



turbine for process plants



Reliable prime mover improves heat balance without need for extra steam-plant investment

Here is another application for General Electric's 5000-hp combustion gas turbine—of interest especially to refineries, petrochemical and other process plants that require considerable amounts of low-pressure steam. In many applications, it is the most economical over-all method of driving large centrifugal compressors.

Lower installed cost

If your plant requires more low-pressure steam—for an added new process or the expansion of present processing—you would ordinarily have to build additional steam-boiler facilities to maintain an efficient heat balance. Using the G-E gas turbine and a waste-heat boiler instead, you receive both needed steam and driving power, improve your plant's heat balance, and eliminate the need to invest in an extra steam plant.

Simplified building construction

For the horsepower it makes available, the building to house the G-E gas turbine is small, simple and inexpensively constructed. Foundations cost less because the turbines and the compressors they drive are relatively small and light in weight. Less manpower is required than with other types of drives, for this G-E prime mover is essentially automatic in operation—even lends itself to remote operation. With only two main rotating parts, upkeep costs are low, and maintenance is mostly a matter of periodic inspection.

Backed by G-E turbine leadership

More than 45 years of turbine-engineering leadership stand back of the G-E combustion gas turbine and assure its operating reliability. Your G-E Apparatus Sales representative will gladly discuss its application to your operation. Meanwhile, send for descriptive 16-page bulletin GEA-5530 to General Electric Co., Section 661-39, Schenectady 5, N. Y.

Combustion Gas Turbines for the Petroleum Industry

GENERAL ELECTRIC

General view of the station from west storage area. Compressor house with auxiliary rooms in center. Masonry office building and fire water tank are to the right. In left foreground is one of the field valve manifolds.

P 650.

Standby and Peak Shaving Project

Near Rockville, Maryland, the Washington Gas Light Company has installed high pressure natural gas storage, propane storage, and mixing facilities

B. C. WHITE

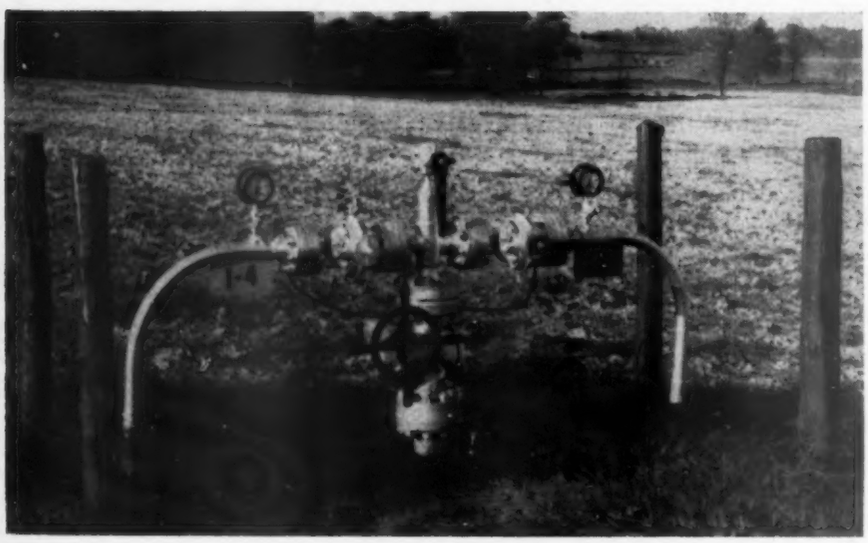
THE Washington Gas Light Company and its subsidiaries distribute and sell gas in the District of Columbia and the adjacent areas of Virginia and Maryland. In 1947, the system was converted to distribute unmixed natural gas, and the water gas sets at East Station were altered to permit the production of oil gas from light oil. In the years following conversion, the peak daily demands on the system increased from approximately 800,000 therms in 1947 to 1,740,000 therms in 1950, and forecasts projected this growth to 2,360,000 therms in 1954. With load increases of this magnitude and the maximum production of oil gas in the converted units, 400,000 therms, it became desirable to provide for additional gas standby and peak shaving facilities. This necessity was underlined by the filing by the system's supplier of a new two-part rate schedule. This new schedule would make one charge for the actual volume of gas delivered and a second charge for maximum daily delivery during any one year. These charges are billed monthly.

An investigation of various methods of providing for standby and peak shaving was authorized. This report covered oil gas, natural gas liquefaction, propane air, and high pressure gas storage. As a result of this report, the construction of a gas storage and mixing plant with a total capacity of approximately 100,000,000 cu ft was authorized.

As it was necessary to make the plant available for use as soon as possible, it was decided to install both high pressure facilities, utilizing the stored natural gas for peak shaving and the propane facilities for standby.

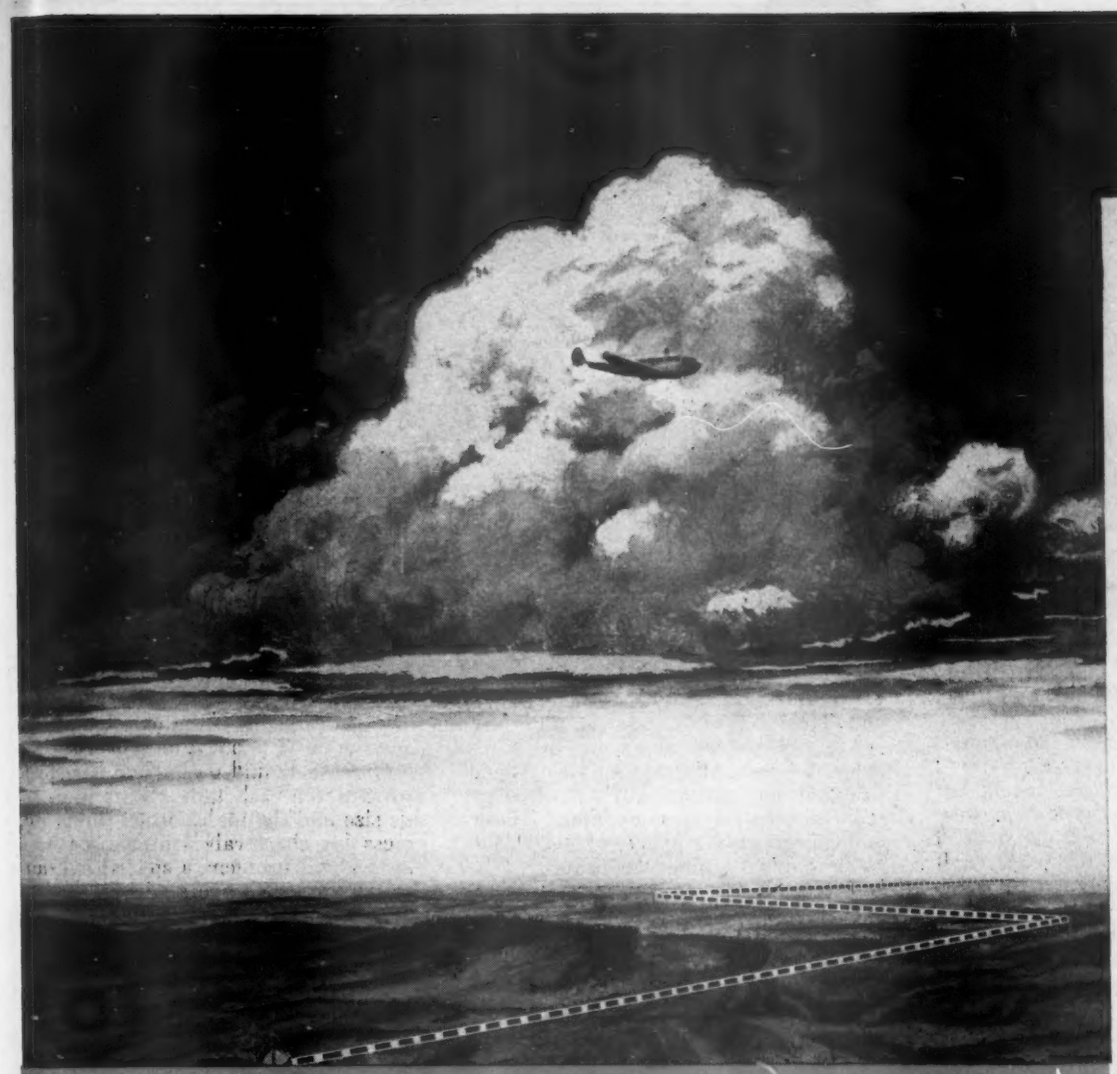
The site selected for the project is approximately 10 miles north of the District of Columbia, within one-half mile of the Rockville, Maryland delivery point, and on the Chillum line, the largest and newest of the four feeder mains for the gas distribution system. At the Rockville delivery point, natural gas is received from the Atlantic Seaboard Pipe Line Company at pressures up to 250 psi gage, through two gas transmission lines.

In view of the high Chillum line pressure, all send-out facilities at the new installation were designed for operation at 250 psi gage, including the propane-air blending system; however, this pressure is of advantage when compressing natural gas for storage. Considering this high line pressure and the limited use of the propane for standby, considerable saving in plant investment was made by reducing the proportion of air in the propane air mixture and raising the heating value to 1500 Btu per cubic foot. Laboratory tests verified that when this



Typical field valve manifold. Each 2-in. valve controls one pipe storage battery.

EXCLUSIVE



Collins Radio equipment flies with these executive aircraft

The Oil and Pipe Line companies listed at the right are a few of the impressive list of those who equip their executive aircraft with one or more Collins Radio communications and navigation aids. The consistent dependability of Collins equipment in operation has been proven to aircraft owners everywhere. They have come to rely on the engineering excellence embodied in every piece of electronic equipment bearing the Collins name.

Collins extensive research departments have been developing a Microwave communications system for many months. The Development, Engineering and Production Departments will soon provide the Oil and Pipe Line industries with a Microwave communications system consistent with the quality and high performance of the radio and navigation equipment now used by their aircraft. Collins has designed and built Microwave apparatus that will meet your requirements. Watch for complete announcement of details.

- Atlantic Refining Co.
- Esso Shipping Co.
- Gulf Research and Development Co.
- Mississippi River Fuel Corp.
- Natural Gas Pipeline Co. of America
- Odessa Natural Gas Co.
- Phillips Petroleum Co.
- Richardson and Bass Co.
- Service Pipe Line Co.
- Sinclair Refining Co.
- Skelly Oil Co.
- Socony-Vacuum Oil Co., Inc.
- Standard Oil Co. of California
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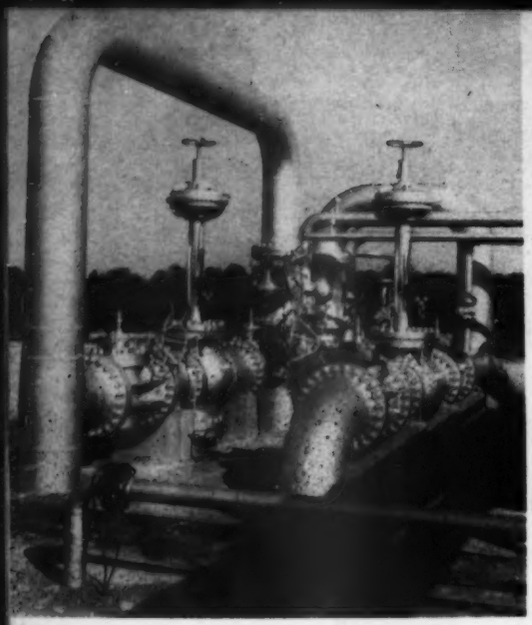
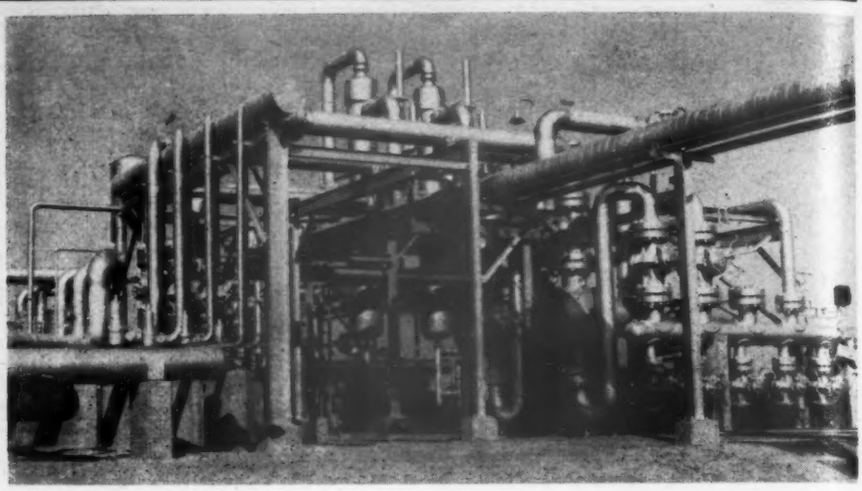


Station discharge manifold with 16-in. diaphragm control valves and by-passes.



Station piping, including high pressure gas heaters and vertical propane vaporizer.

high propane air was blended with natural gas in the ratio of 4 to 6, the resulting gas mixture would be interchangeable with straight natural gas.

Anticipating future gas loads, the send-out facilities for the station were designed to 7,000,000 cu ft per hour of straight natural gas or 6,000,000 cu ft per hour of the propane-air natural gas mixture. The natural gas is supplied for storage at high pressure in pipe storage units. The 1,030,000 cu ft per hour of air required is supplied from four Worthington gas engine driven compressors, each with a name plate rating of 1200 bhp utilizing two stages of compression. These engines operate over a speed range of 160 to 320 rpm and are complete with automatic shutdown devices that shut off the fuel supply and ground the ignition in event of high water temperature, low oil pressure, or overspeed.

Each compressor has two air compression and two gas compressor cylinders. either pair of which can absorb the full power output of the gas engine.

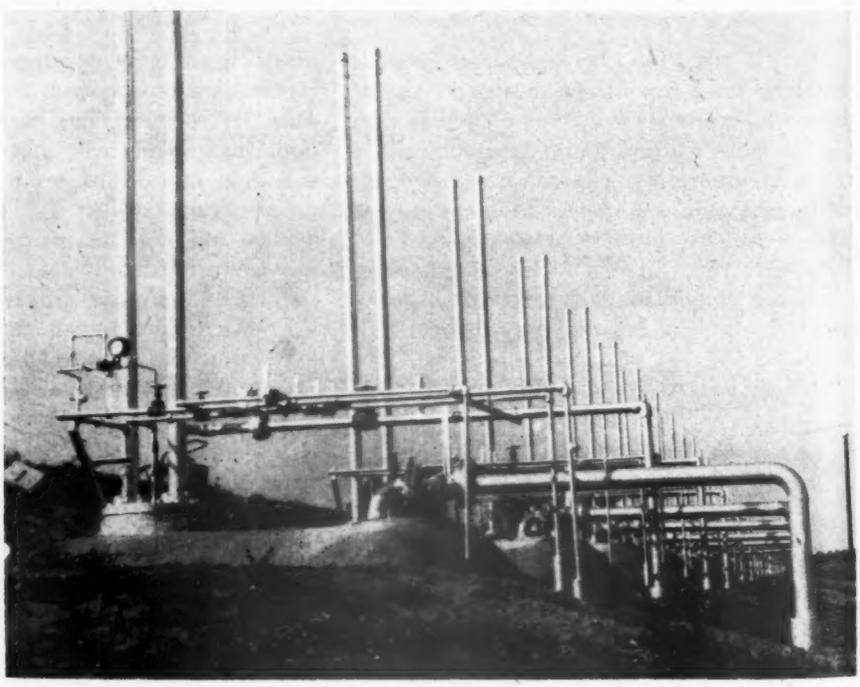
Gas to be stored is dried before compression in two stages to 2240 psi gage. The gas dryer is a fully automatic two-chamber unit operating on a 3-hr cycle, utilizing 9000 lb of activated alumina desiccant and reducing the water content of the gas to less than 0.5 lb per 1,000,000 cu ft. For reactivation of the desiccant, about 1600 cu ft per minute of gas are heated to 325 F by a 250-kw electric heater and passed through one of the chambers.

The storage units are seamless steel units 24 in. OD by approximately 40 ft 8 in. long with integrally forged heads. The 2864 units are arranged in groups of 16 to 45. Units within groups are spaced 8 ft end-to-end and 15 ft center-to-center, and suitably manifolded to a 2-in. header with valve and pressure gage, and these in turn to 6-in. field headers. At two locations, recording thermometers have been installed to measure the temperature of the gas in storage. As the units were installed, the location, serial number, internal volume, and length of each were recorded. From the storage pressure, temperature, volume, and compressibility factors, the exact amount of gas in storage may be calculated. All gas storage units, piping, and headers, with the exception of valves and pressure gages, are installed below ground. All surfaces are coated, wrapped, and cathodically protected to reduce corrosion to a minimum. These units have a gross capacity of 66,800,000 cu ft of gas, of which 56,800,000 cu ft are available for return to the distribution system at design rates.

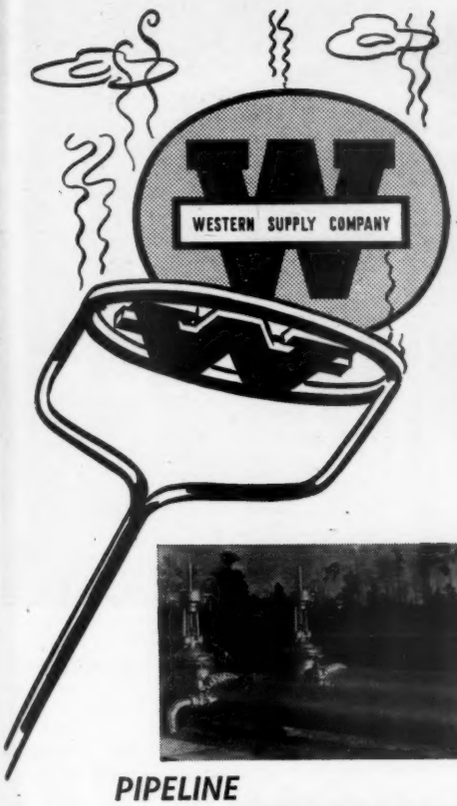
Gas that is withdrawn from storage is heated with steam before its pressure is reduced through one or more of the special control valves. This heating minimizes the possibility of hydrates forming in the gas.

Propane for mixing with air and the natural gas is stored in 25 steel tanks, each with a gross capacity of 30,000 gal. As these vessels are covered with earth, they have a net storage capacity of 680,000 gal, equivalent to 41,700,000 cu ft of gas. Space also has been allowed for the addition of 25 more propane tanks.

Propane may be withdrawn from storage at rates up to 680 gpm. For this purpose, a 4-in. liquid outlet line has been provided for each tank. With lines of this size and the high normal flow rate, excess flow check valves are not feasible. To meet this problem, a special hydraulic operated valve operated by a hydropneumatic system is installed in each tank outlet. These valves will close automatically in event of fire around any of the tank connections, propane pumps, or metering equipment. They also may be tripped manually at any of four points. The hydraulic valves are arranged for operation in groups of five so that groups of five tanks may be placed in service. Once the system is tripped, all tanks are



Buried propane tanks with 4-in. liquid outlets. Portions of tanks not covered with earth have 4-in. of insulating concrete.



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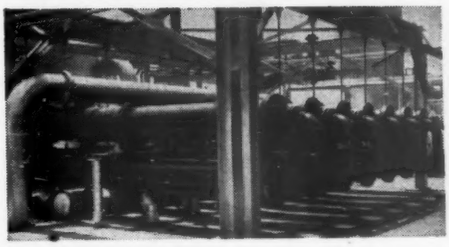
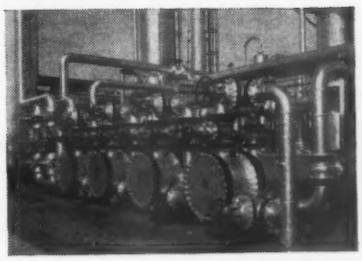


PETROCHEMICAL



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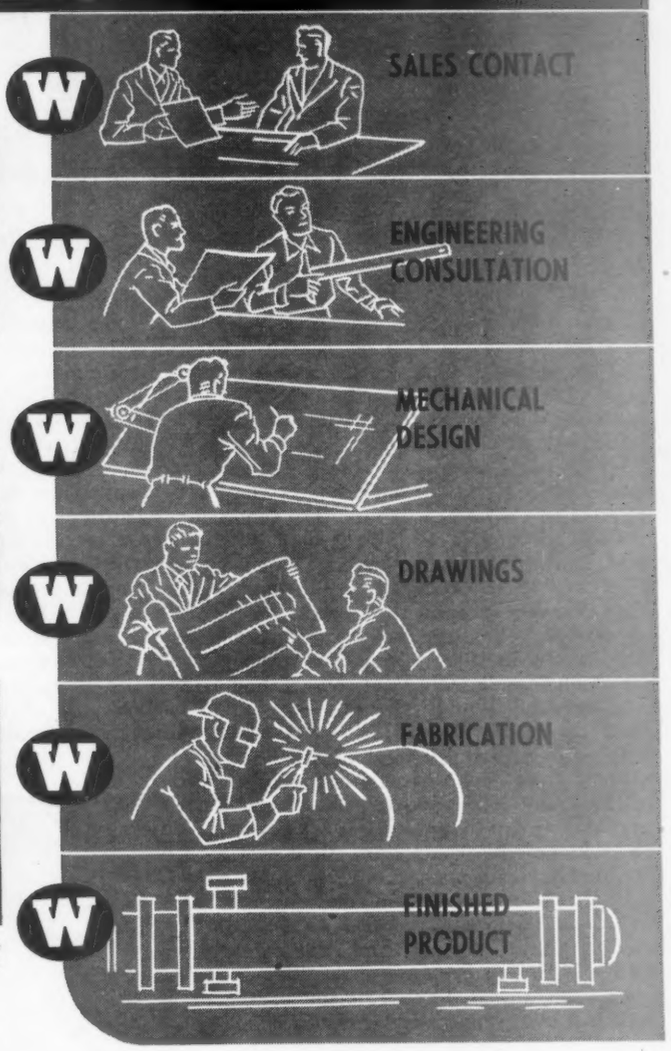

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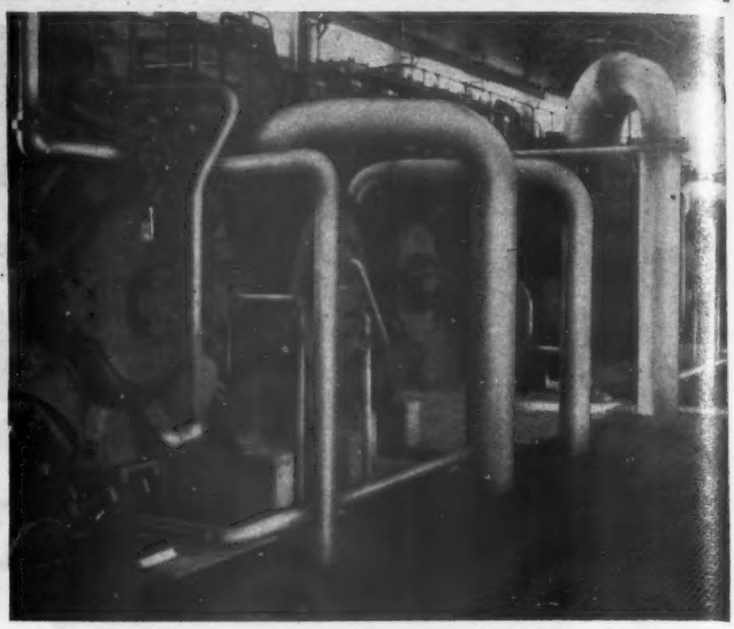
Propane liquid transfer pumps. Pump barrels are in the concrete pedestals.



Compression cylinders on gas engine driven compressors. Compressor cylinders on one machine are from left: First stage air, second stage gas, second stage air, first stage gas.

shut off and the propane pumps stopped in 5 sec.

The propane liquid is transferred from storage to the vaporizers by two centrifugal pumps, each capable of handling 340 gal per minute.

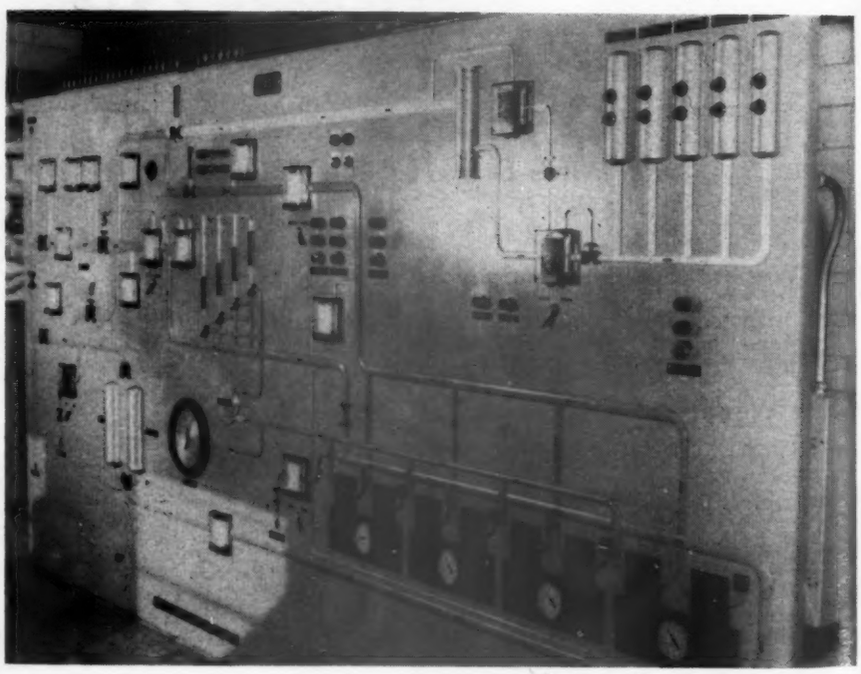
From the storage area, the propane liquid flows to the air intercoolers and aftercoolers where it cools the compressed air and is itself preheated before flowing to the vaporizers. Vaporizers are of the vertical once-through type utilizing steam in their tubes. As a precaution, the superheated propane vapors flow through a knockout drum, on which is mounted a level control that will stop all liquid flow in event of liquid carryover.

Propane vapors, air, and gas all flow through the regulator room, but mixing of them takes place outside. The proper proportions are maintained at all times by Askania ratio controllers. To insure constant metering conditions, the pressure of the propane is held constant upstream of the mixing control valve, as also is the air pressure. The ratio controller for the propane-air mixing is automatically adjusted by a calorimixer to maintain the proper heating value. This control point may be reset from the control board as desired.

Orifice type recording flowmeters have been provided for the natural gas to storage, compressor fuel, boiler fuel, process air, propane liquid gas from storage, and gas flow in the Chillum line. To provide for a more stable system, the propane liquid to the vaporizers is controlled by the flow recording controller, which, in turn, is reset by the propane pressure. The gas flow from storage may be used for control with a manually set control point. The flow recording controller in the Chillum line is used to regulate the rate of odorization by controlling a small variable speed positive displacement pump. All flows are measured locally by differential converters that transmit an air signal to the control board. In many cases, the anticipated flow ranges exceeded a 3 to 1 ratio. For these instances, two converters are provided and a selector valve is situated on the control board, so that the operator may utilize the converter best suited for the conditions.

All principal data are recorded on a control graphic control board, which enables the operator to visualize quickly the operating conditions throughout the plant, including compressor engine speeds and loading, propane tank area operation, flowing quantities, pressures, and temperatures. From this panel, the operator may change the operating conditions throughout the plant. At this point, the operator has only to change the gas flow rate when mixing propane and air with the natural gas and the propane and air flows will be adjusted automatically, including the output from the compressors. In air service, all compressors are under complete automatic control from a special panel in the compressor house. After any change in flow rates, this control will adjust the speeds of the engines and load or unload the air cylinders as required, and in the proper sequence, utilizing the air pressure as the primary control. Under this control, the air pressure returns without hunting to within 1 psi of the set point after any flow change.

In a standby and peak shaving plant



Main control panel located in control and office building.

The Author

B. C. White, engineer, Stone and Webster Engineering Corporation, Badger Process Division, was graduated from Northeastern University in 1938 with a BS degree in mechanical engineering. After graduation he spent a year in the Edgar Station of Boston training. In 1939 he joined Stone and Webster and was employed in the design division until 1942, when he was transferred to engineering work in the Badger Process Division. From 1944 until 1948 he was in charge of all pressure vessel and heat exchanger work for this division. In 1948 he was made responsible for all work on five high pressure gas and propane installations in Illinois, and since that time has been in charge of several gas and propane air blending plants. Currently he is in charge of engineering for the plant discussed in this article.

White is a registered professional engineer in Massachusetts and the province of Alberta, Canada; a member of AGA and New England Gas Association, and represents Stone and Webster on the ASA A31 Subcommittee No. 8.

it is desirable to reduce the number of operators assigned to the station to a minimum. By utilizing controls to the greatest extent consistent with safe operation it is possible to run this plant with three operators per shift.

The only gas entering the office and control building is in low pressure sample lines for the calorimeters, calorimixer specific gravity recorder, and the gas-fired water heater.

The temperature of the engine jacket water is held constant by bypassing a portion of it around the coolers.

The jacket water is circulated through a closed system by four 30-hp jacket water pumps. Cooling of the water is accomplished in three air-cooled units, each equipped with one 16 ft diam fan with four blades. The fans are driven by 20-hp electric motors through speed reducers. Similar coolers but with more fans of smaller size are used to cool the gas after the first and second compression stages. For these units, each tube bundle is part intercooler and part aftercooler, with three fans for each tube bundle.

Air at 250 psi gage for starting the gas engine driven compressors is obtained from three 3-ft diam by 8-ft receivers, which are supplied by two 15-hp starting air compressors. A third auxiliary 15-hp compressor supplies air at 100 psi gage for operation of the instruments. This air is dried in a semi-automatic unit that reduces its dew point to 5 F in the winter. In case of failure of the instrument air compressor, instrument air may be obtained from the starting air system through a regulator.

To insure quick starting and warm-up of the gas engines, a heating coil has been installed in the jacket water tank and a 5-hp warming water pump included in the jacket water system.

Steam for heating the jacket water, as well as vaporizing propane, heating gas and building, is supplied from four low pressure gas-fired steam boilers, each rated at 17,000 lb per hour. The building housing these units is arranged to operate under a slight positive pressure and all air for combustion is supplied through fans and heating coils taking their supply from the roof. This arrangement minimizes the possibility of propane vapors getting into the combustion air.

Also situated in the boiler room are the two fire pumps, one electric motor driven and the other gas engine driven, and a small fire system pressuring unit. The fire protection system is maintained under a pressure of 80 psi gage at all times and if the pressure should fall to 75 psi gage, such as when a hydrant is opened, the electric motor driven fire pump would automatically start. Both fire pumps are rated at 500 gpm at 125 psi gage.

In an adjacent room are the main electrical switchboard and a 375-kw gas engine driven emergency generator. The generator was selected to carry the plant loads at approximately one-half capacity during a power interruption, and will start automatically when needed. * *

... On ROSKOTE, of course — that's the one safe bet for complete pipe protection.

Roskote is applied *cold*. That means money saved by elimination of kettles and man-hours by faster operation and reduced hazards.

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Roskote retains its tough flexible film, without brittleness or sag through a temperature range of −40° to 375° F. It provides an electrical resistivity of 20 megohms per square foot. It is resistant to acid, alkali, salt and moisture.

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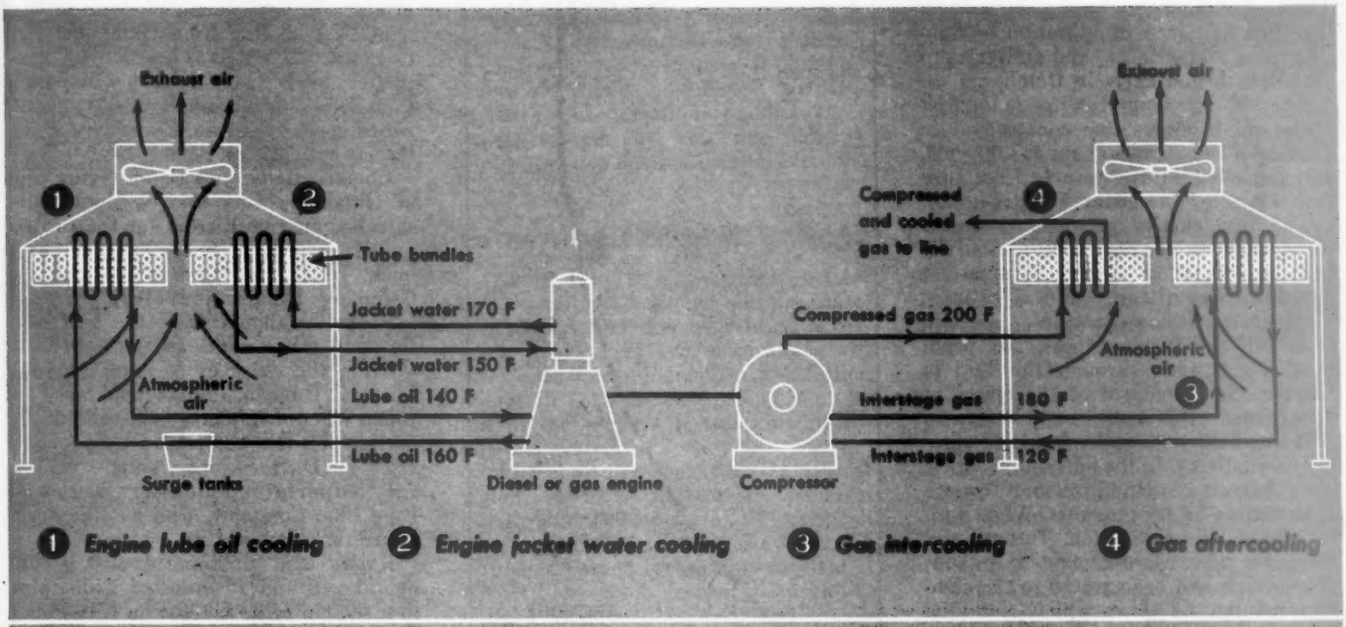

in high-pressure gas compressor stations

In a typical high-pressure gas compressor station, two ALCO Aircoolers shown in the illustration perform four major cooling duties: (1) engine lube oil cooling (2)engine jacket water cooling (3) gas intercooling (4) gas aftercooling.

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Sarnia Line Delivers Products to Toronto

The first gasoline ever delivered to Toronto by pipe line arrived at Toronto in November through Imperial Oil's Sarnia products pipe line.

Gasoline pumped from Imperial's refinery at Sarnia is now arriving at the company's tank farm on Toronto harbor at a rate of 35,000 gal an hour. To maintain the same rate of delivery by rail, 120 tank cars a day would be needed. The line has been in operation to London since early March, and deliveries to Hamilton began early in October.

The 188-mile-long pipe line is the first major oil products line constructed in Canada. The cost was about $11,000,000, and Comstock-Midwestern Ltd., of Leaside, Ontario, was general contractor.

The line carries products manufactured at Imperial's Sarnia refinery to the heavily populated industrial areas at London, Hamilton, and Toronto. Through it will flow gasolines, diesel oil, stove oil, and furnace fuels. The products are shipped through the line in batches. Strict control of the speed of flow prevents mixing.

It was built to provide surer and more flexible delivery. In the past, oil products were delivered to Hamilton and Toronto from Sarnia by lake tankers. When winter closed lake navigation, Toronto and Hamilton areas were dependent on supplies which had been stored in the summer months, or those which could be brought in by rail and road. Pipe line operation is not affected by the weather, and can deliver the year round.

The main line consists of 132 miles of 12-in. diam pipe, from Sarnia to Waterdown, and 56 miles of 10-in. diam pipe from Waterdown to Toronto. Hamilton is served by two 6-in. spur lines from Waterdown each 6½ miles long. These spurs make a one-mile crossing of Hamilton Harbor.

The final stretch which has been under construction this summer—Waterdown to Toronto, via the Don Valley—was tested recently. The pipe was filled with just over 1,000,000 gal of water and then tested to 1200 lb pressure. The test completed, engineers began running off the water. It took 30 hours to empty the line of water. Behind the water was gasoline which had been dispatched from Sarnia two days before. When it reached the terminal at Ashbridge's Bay it was piped into nearby storage tanks.

The line has a present capacity of 39,000 bbl, or 1,365,000 gal a day, but with the addition of another pump station, this can be increased.

Interchangeability of Gases Reported On

When a utility changes over from manufactured to natural gas, differences in composition of the two gases require conversion and adjustment of practically all appliance burners in the service area. Further, in the event of an emergency, the former type of manufactured gas cannot then be re-substituted.

With the above in mind, the manufacture of gases that are completely interchangeable with natural gas has become a major interest of the Institute of Gas Technology, affiliated with Illinois Institute of Technology, Chicago. The American Gas Association under its PAR (Promotion - Advertising - Research) Plan is sponsoring research on natural gas substitutes from coal and oil.

Present studies are concerned mainly with improving the substitutability of oil gases for natural gas through modifications of their compositions by one or more of these techniques:

(a). By mixing or dilution with inerts.

(b). By reduction or removal of specific aromatic hydrocarbons through scrubbing, freezing, or compression.

(c). By control of severity of cracking in the production of oil gases.

(d). By reduction or removal of unsaturated hydrocarbons and hydrogen through catalytic auto-hydrogenation.

Results of studies of *a*, *b* and *c* above are presented in an Interim Report, "Interchangeability of Oil Gas and Natural Gas," by D. L. Nicol, R. A. Brown, and H. R. Linden, which may be purchased from the Institute at $2.50.

Continental's crude oil line.

Work Begins on New Continental Pipe Line

Contracts have been awarded and construction begun on a $4,180,000 12-in. crude oil pipe line from Oklahoma City to Wichita Falls, Texas, it was announced in Ponca City by W. L. Kygar, president of Continental Pipe Line Company, a subsidiary of Continental Oil.

The 127-mile pipe line, which will have a daily capacity of 53,000 bbl of crude oil, will connect with Continental's 8-in. line from Oklahoma City to Ponca City. It is scheduled for completion by January 1, and will enable Conoco to transport crude from its fields in the Wichita Falls area to its largest refinery at Ponca City.

Construction crews began laying pipe at Oklahoma City and Wichita Falls, said Kygar. Contractors for the project are R. H. Fulton and Company, Lubbock, Texas, and Western Construction Company, Hobbs, New Mexico.

From Oklahoma City, the new pipe line will travel south to Wichita Falls, skirting the cities of Norman, Purcell, Lindsay, Duncan, Comanche, and Waurika. When completed, the Oklahoma portion of the carrier will be supervised by D. S. Skinner, Oklahoma district superintendent for Continental Pipe Line Company, who has his headquarters in Ponca City.

Kygar also announced that Continental will add 18 miles of 12-in. pipe to a section of its Oklahoma City-Ponca City line, roughly from Perry to Tonkawa. This will result in increasing the daily capacity of that line from 21,000 to 38,500 bbl, he said.

Damaged Narrows Line Repaired, in Service

A second natural gas line into New York City has been completed and is now available to serve the five New York gas distributors of Transcontinental Gas Pipe Line Corporation, the company has announced. The 24-in. line enters Brooklyn from Linden, New Jersey, crossing Staten Island and The Narrows of New York Harbor. Transcontinental's other line serving New York City crosses the Hudson at 134th Street.

Delay in putting into service the line across The Narrows resulted from a ship's anchor damaging the pipe after it had been pulled across but before the trench could be backfilled.

Under the direction of Transcontinental's engineers, Meritt-Chapman and Scott handled the repair job. Divers had to cut the 6600-ft line under water. Pontoons were then attached to lighten the load. Four derrick barges, braced against the tide, hauled up the severed ends and positioned them securely on a repair barge. A new section was welded into the line, X-rayed, and coated.

The re-joined line was lowered in the trench, tested, purged, and then filled with gas. Backfilling the trench with suitable soil has progressed to the point where it is believed that no new damage to the line is probable.

Two Distribution Firms Organized in Houston

Two new firms to handle distribution of production and pipe line equipment for the oil industry in Southwest Texas have been established in Houston. Both

J. L. Joplin

E. L. Rolfs

J. D. Brance

the Oil & Gas Supply Company and Peddlers, Inc., are headed by J. L. Joplin. Joplin formerly was division manager in Houston of Buda Engine and Equipment Company, and chairman of Buda's Texas operating committee.

E. L. Rolfs is vice president. He is a founder and former president of Crutcher-Rolfs-Cummings, Inc., Houston pipe line construction company. J. D. Brance, the secretary-treasurer, is the past president of Brance-Krachy Company, Inc., Houston, an electrical power transmission concern.

Distributed through Oil & Gas Supply Company are Worthington gas compressors, air compressors, rotary pumps and centrifugal pumps, Marathon electric motors and generators, Marlow self-priming pumps, and Onan light plants.

Peddlers, Inc., specializing in pipe line equipment, is the South Texas distributor for Gaso Pumps and sole distributor of Enterprise Engines for the petroleum industry.

O. F. Moore Elected Head Pipe Liners Club

O. F. Moore, vice president and manager of the Pipe Line Department, Ohio Oil Company, was elected president of The Pipe Liners Club at the annual meeting in Chicago held during the API convention. He succeeds R. B. McLaughlin, chairman of the board, The Texas Pipe Line Company. J. L. Latimer, president of Magnolia Petroleum Company, was named vice president, and Oliver C. Klinger, Oildom Publications, secretary-treasurer.

J. H. Wood, Jr., vice president and general manager, the Atlantic Pipe Line Company, is a new member of the board of governors. Other members are McLaughlin, Latimer, Moore, Loren B. Kahle, assistant to the pipe line advisor, Standard Oil Company (New Jersey), and J. L. Burke, president of Service Pipe Line Company.

Primer on Pipe Line Construction Published

"A Primer of Pipe Line Construction," told in layman's language with accompanying pictures, was published November 20 by the University of Texas Petroleum Extension Service.

The publication was sponsored and partially financed by the Pipe Line Contractors Association of Dallas. John Woodruff of the Petex staff wrote and edited the 100-page book.

Woodruff was assisted by an advisory committee headed by James P. Neill of Austin. Other committeemen included N. A. Saigh of San Antonio, Richard A. Gump of Dallas, and John H. Williams of Tulsa, Oklahoma.

Others from the pipe line industry who worked on the publication included Richard Finnie of San Francisco, David Kerr of Bartlesville, Oklahoma, G. H. Osborne, Larry Favrot, George Peterkin, Ferrile Young, and Bert Mast, all of Houston.

Gulf, Humble, and Shell oil companies provided photographs, which were supplemented with originals from pipe line contractors and pictures taken in the field by Hal Stegman and Jim Felts, Petex staff photographers. Pen and ink drawings were done by Rudy Gonzales and Harold Clayton, Petex staff illustrators, and layout was by Pat Taylor and Lee Krause of Petex.

Copies are available at $1 each from Petroleum Extension Service, University of Texas, Extension Division, Austin.

Growing Use and Reserves of Natural Gas

Gazing into a hydrocarbon crystal ball, a leading researcher told the American Gas Association convention in Atlantic City that by 1957 natural gas will have been expanded into a $14 billion operation — an increase of $5 billion by one of the nation's fastest growing industries.

Astronomically speaking, Dr. Gustav Egloff, research director of Universal Oil Products Company of Chicago, felt that eventually much more than the estimated proved recoverable reserves of 500 trillion cubic feet of natural gas will be found underground and underwater in the continental United States.

Envisioning underground frontiers, Dr. Egloff stated that thus far about 98 per cent of the million square miles of land area overlying our sedimentary formations remain to be thoroughly explored by the drill. Moreover, he pointed out that "natural gas has been discovered at a much faster rate than petroleum and natural gas liquids in recent years."

Statistics showing that natural gas "supplies will be maintained well beyond the present century," were cited by Dr. Egloff. He interpreted such reserves as meeting all demands and upholding "the favorable competitive position of the industry" in the fuel field far into the future.

Much of the continuing increase in the use of natural gas, said Dr. Egloff, most likely will be "in the fields of space heating, cooking, heat treating, and chemicals production." He added that close to a million homes installed gas heating facilities during the 1951-52 heating season and another 1,100,000 new customers are anticipated for 1952-53.

"The greatest increase in natural gas use from 1951 to 1975, around 180 per cent," was foreseen by Dr. Egloff "in residential heating where the demand is expected to rise from 1.5 to 4.2 trillion cubic feet." In sum, he said "the growth of the natural gas industry will depend to a considerable extent upon the increasing use of natural gas in space heating."

Natural gas and liquefied petroleum gas have been used more markedly for cooking from 1940 to 1950, said Dr. Egloff. He reported that the 16,776,000 home units using gas for cooking in 1940 had been increased by 7,889,000 by 1950—for a total of 24,656,000 home units cooking with gas.

In the industrial field Dr. Egloff cited that more than 50,000 factories were using natural gas in 1951, double the number in 1941. He spelled out the increased use from 1 trillion cubic feet in 1932 to 3.392 trillion cubic feet in 1951, making a 240 per cent increase.

Natural gas, Dr. Egloff went on, also is a "major raw material for the skyrocketing $2 billion petrochemical industry," which now supplies a quarter of the total chemical requirements and may be the source of much more in future years although at present 80 per cent is for carbon black. With an eye toward national defense, he hailed such synthetics because "they assure the United States of self-sufficiency in cases of either temporary or permanent shortages of raw materials."

Texas Gas Opens Houston Office

Texas Gas Transmission Corporation has announced the opening of an office in the Melrose Building, Houston, Texas, to facilitate its gas supply activities.

Houston was selected for location of the new office because many of the companies with which Texas Gas deals on gas supply matters have offices there, it was explained.

The Houston office, the company said, represents a further move by Texas Gas to develop its program for obtaining new sources of natural gas. Fred Schall, chief geologist of the company, has been transferred there from Shreveport, Louisiana, where he formerly made his headquarters. Other personnel will be assigned in the near future.

Texas Gas has two other offices in the gas supply area. The gas supply department is in the Petroleum Building, Shreveport. Lake Charles, Louisiana, is headquarters for the company's two gas-gathering subsidiaries, Louisiana Natural Gas Corporation and Texas Northern Gas Corporation.

AGA President Predicts Further Advances in 1953

Today the natural gas industry is booming. It has soared into public acceptance, and because of its spectacular advance, much has been gained by the entire gas industry. Industry statistics indicate continued widespread growth and development. The trend of the gas industry is up — growth, expansion, and progress are key words of the nation's fastest growing industry.

This optimistic viewpoint was expressed at the 34th annual convention of the American Gas Association at Atlantic City, New Jersey, by Charles E. Bennett, president, The Manufacturers Light and Heat Company, and president of the trade association of the twelve-billion dollar gas industry.

Total gas industry revenues have increased 22.6 per cent in the last 18 months, Bennett said. Long term capital financing by straight operating gas utilities and pipe lines is up more than 20 per cent since 1950. It is contemplated that 5.6 billion dollars will be spent for new construction in the next 5 years. Utility sales of gas rose 8.8 per cent last year and gas customers gained 4.2 per cent to reach 26 million. Proved recoverable reserves are up 8.2 trillion cubic feet to an all-time high of 193.8 trillion cubic feet. The annual tax burden of the gas industry is now 490 million dollars, he pointed out.

The gas industry today faces the most serious challenge in its history, Bennett declared. He said he knew the industry had the ability to meet this challenge but it must realize that very significant years lie ahead. Its very achievements have made the industry vulnerable to competition from all sides.

The gas industry must meet competition for steel, for manpower, for increased rates, and for the investment dollar. Great competition surrounds the sale of gas as a fuel and the sale of its appliances and related equipment.

As an industry already experiencing the heavy load of regulation the gas industry is threatened with even more regulation in the future, the association president said. Because of that regulation by numerous governmental bodies the industry faces a "squeeze play" across the land between runaway costs of doing business and an inevitable lag in the granting of permission for urgently needed higher rates.

Bennett declared the industry has the greatest opportunity in its history to continue its phenomenal progress, if it recognizes these danger signals and plans to meet its challenge. He advocated maintaining and improving the gas industry's public relations; strengthening its earnings position and intelligent planning in advance to meet each new problem. Coordinated procedure must be developed to unite the industry as a cooperative, dynamic enterprise. The gas industry must maintain its position as a free enterprise leader.

Pointing out some of the measures the American Gas Association was taking to meet the problems of the industry, he declared the industry's Promotion, Advertising and Research (PAR) Plan had been a great success. More than $2,000,000 was subscribed this year to finance this intensive, coordinated effort to improve the production and utilization of gas and to maintain its position of leadership as a household and industry fuel.

More than 45 research projects are being carried on in technical fields of utilization, production, and transmission.

Safety in the gas industry has received much attention in the past and committees delegated to promote safety have been very active this year. The frequency of accidents to gas industry employees has been steadily decreasing for the past four years. The National Safety Council figures indicate there has been a 12 per cent reduction in the frequency of employee accidents in the first six months of 1952 as compared with 1951.

Gas companies are in a very unusual and difficult position today, he said. They have to pay more for gas, more for labor, more for equipment, and more in taxes. The industry is doing its utmost to bring better living to more and more people. It has received the adulation of the press, but it has not given the press the opportunity to tell the rest of the story. For unless more people understand the impossibility of doubling labor costs and doubling material costs without commensurate increases in the industry's product selling price, then the nation will never receive the ultimate advantage of gas service.

Even more regulation of business and industry is being advocated. A new theory of rate-of-return and other disturbing precepts are being advanced. These are endangering the gas industry's ability to raise the capital necessary to render the type of service that the public demands and deserves.

Declaring that he did not say that all regulation is bad, the AGA president said that our nation's industrial growth and its industry's business progress was not achieved by regulation, either creeping or galloping. Bureaucratic supervision is not required for our country's prosperity. Private enterprise is vital for our future, and continued individual effort will carry the gas industry to even greater accomplishments, Bennett said.

Gas Industry Formulating Safety Code for Pipe

At a three-day meeting of a newly organized subcommittee of the American Gas Association held in Chicago recently, work was begun on the formulation of a safety code covering the material, design, fabrication, installation, testing, and operation of gas pipe lines and related facilities.

Announcement was made in June by the American Gas Association and the American Standards Association that F. A. Hough, vice president, Southern Counties Gas Company of California, Los Angeles, would head a new national committee concerned with gas transmission and distribution safety. The committee, known as Subcommittee No. 8 on Gas Transmission and Distribution Piping, of Sectional Committee on Code for Pressure Piping, B31, is sponsored by the American Society of Mechanical Engineers, as well as AGA and ASA. Hough serves as chairman because of his recent appointment as representative on the sectional committee of the AGA's Natural Gas Department.

Subcommittee No. 8 will use as its starting point a forthcoming document known as Section 8, on Gas Pipeline and Distribution Systems, which is a consolidation of those parts of the Code for Pressure Piping B31 pertaining to gas piping. The subcommittee will revise and expand this section where necessary, and, upon its approval by ASA, will publish it as a separate document known as "Section 8, Code for Pressure Piping B31.1." It will also be included as the last section in future editions of the B31 Code. The Chicago meeting was devoted to full discussion of pipe line problems and a careful review of existing requirements to determine to what extent the forthcoming Section 8 requires modification or expansion to reflect modern materials and technology.

In addition to Chairman Hough, officers of Subcommittee No. 8 are: Walter H. Davidson, Transcontinental Gas Pipe Line Corporation, Houston, vice chairman, and chairman, Subgroup on Construction and Operating; C. F. DeMey, Columbia Gas System Service Corporation, New York, vice chairman, and chairman, Subgroup on Pipe; C. T. Schweitzer, Southern California Gas Company, Los Angeles, secretary, and chairman pro tem, Subgroup on Design Stresses; B. T. Mast, Tennessee Gas Transmission Company, Houston, chairman, Subgroup on Compressor Stations; and Frank S. G. Williams, Taylor Forge and Pipe Works, New York, chairman of Subgroup on Fabricating Details and Mechanical Design. Williams also is chairman of Sectional Committee, Code for Pressure Piping B31, of which Subcommittee No. 8 in a part.

New Edition API Lease Tank Bulletin Published

The American Petroleum Institute announces the publication of a third edition of the bulletin on Recommended Practices in the Setting, Connecting, Maintenance and Operation of Lease Tanks.

The new edition was prepared by the Subcommittee on Lease Tank Practices of the Institute's Division of Transportation. R. Charles Nicholson, Shell Pipe Line Corporation, is chairman of the formulating committee on which are representatives of producers, pipe line carriers, and manufacturers.

The Bulletin is a guide for the installation and operation of lease tanks when such tanks are used as origin tanks for pipe line shipments.

Copies of the Bulletin identified as API Bulletin 1103, Third Edition, September 1952, may be ordered at 25c a copy from J. A. McNally, American Petroleum Institute, 50 West 50th Street, New York 20, New York.

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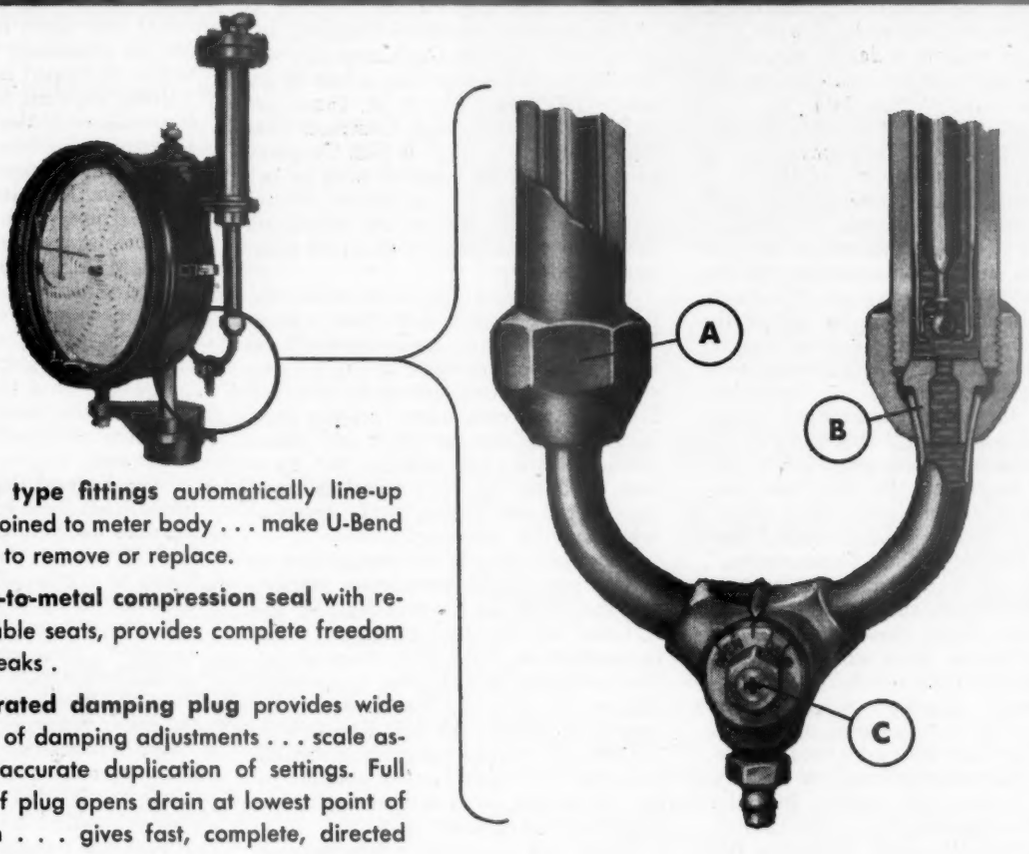

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News

IGT Announces Home Study Course Plan

The Institute of Gas Technology is extending its educational services to the gas industry by bringing instruction, through home study courses, to students and utility employees who are unable to attend classes at the Institute.

The courses are being prepared in cooperation with the American Gas Association, which appointed a committee of utility executives to act in an advisory capacity. This cooperation, and the assistance of gas industry specialists as contributors and reviewers, give the IGT home study courses a degree of authority and comprehensiveness seldom attained in works of this type.

The first of these courses, "Natural Gas Production and Transmission," is by Joseph D. Parent, dean of IGT.

The carefully considered plan adopted for the texts is to present the subject matter so it can be understood by persons with little or no training in the fields under discussion; yet, the coverage of all subjects is to be sufficiently comprehensive that the courses can be integrated with cadet engineering programs, and can serve as "refresher courses" for more experienced utility personnel, particularly the many whose work has been so long restricted to one phase of operations that they have lost contact with the progress of the others. These objectives have been met in "Natural Gas Production and Transmission." Chemical, physical, engineering, and geological fundamentals are offered early in the course, to aid those who have had no instruction in these subjects.

The student then progresses, in logical sequence, through each phase of production, gas conditioning, and transmission. Sections with advanced mathematical manipulation are so written that any person not familiar with the mathematics employed may omit the calculations, and by merely accepting the solutions as given, continue reading the sections with understanding.

Sound engineering has always been wedded to economics, and their relationship is maintained in this course. Economic and legal aspects of certain operations are discussed in the chapters dealing with those operations. The closing chapters contain information essential to an understanding of the business activities (and problems) of natural gas companies.

The course is offered under several plans, to suit the needs and circumstances of individual enrollees, or groups of enrollees, and to fit into employee training programs of companies.

Under the basic plan, on enrollment the student is supplied with the complete text. He is expected to study each chapter, consult a reasonable number of the references given, and submit a written report on each assignment. These reports may be submitted as rapidly as they can properly be prepared; they will be graded by a member of the Institute's teaching staff and returned with constructive criticisms.

The average student can successfully complete this course in one year if he devotes a few hours per week to conscientious study of it. He is required to complete it within two years of his date of enrollment; failing to do so, he releases the Institute of further responsibility for instruction in this course.

Satisfactory completion of the course will be recognized by the award of a suitable certificate.

Provision has been made for "time payments" in three installments.

California Expansion Work Under Way

Expansion of Southern Counties and Southern California Gas Companies section of the Texas pipe line to handle another 150,000,000 cu ft of Texas gas daily is now under way. Contracts have been awarded to the J. B. Gill Company of Long Beach for concrete work on two booster stations, one at Desert Center midway between Blythe and Indio, and the other at Cactus City about 20 miles east of Indio.

Work on these two compressor stations will be broken down into a number of separate jobs, it was learned from C. F. Briscoe, manager of engineering services. Other contracts to be awarded following the excavating, grading, and installation of concrete work and underground utilities will include: (1) Erection of buildings, (2) installation of machinery and piping, (3) electrical work, and (4) painting.

These two stations will be gas turbine driven, centrifugal compressor stations at which General Electric 5000-hp gas turbines will be used to create a gas pressure boost on the 30-in. transmission lines between the Blythe compressor station and Los Angeles. They are designed to handle the full line flow of 555,000,000 cu ft of gas daily. Provision has also been made for any possible future expansion by simply changing the impellers and diffuser rings.

Intake and discharge valves have already been stubbed off of the main lines so that the stations can be tied in when completed without a line shutdown.

In addition to the 10,000 hp to be provided by these two stations, another 3520 hp is to be added at the Blythe compressor station through installation of two 1760-hp Clark units. This work, which is to get under way soon, is expected to be completed by the early part of the year.

Pipe line construction by Southern Counties and Southern California to handle the additional 150,000,000 cu ft will involve the laying of 20.3 miles of 30-in. loop line from Whitewater east, paralleling the present Texas line, and 6.3 miles of similar loop line from the Colorado River to the Blythe compressor station.

The loop west of Indio is expected to be completed about February 1, and the loop feeding the Blythe compressor station about March 1.

Cost of the two companies of the new construction is estimated slightly in excess of $5,000,000. Consolidated Western Steel Company has the contract to fabricate the pipe, and the compressor units are on order.

Separate Producing Company

Northern Natural Gas Company has announced the organization of a new natural gas production company. The new company, a wholly owned subsidiary, is called Northern Natural Gas Producing Company.

All Northern owned wells and leases in the Hugoton field of Kansas and the Panhandle field in Texas, plus all wildcat acreage in Nebraska, Texas, Kansas, North Dakota, South Dakota, and Canada were transferred to the new subsidiary on October 31. Gas purchase contracts have been executed by Northern and its subsidiary for life of production of the developed leases.

John Merriam, president of Northern, is president of the producing company. Directors are Merriam, Mark Adams and W. I. Robinson of Wichita, Larry Shomaker, John Hanley, and A. B. Dilworth. The last three are vice presidents of Northern and also of the new company. M. L. Mead, assistant to Northern's president, also is a vice president of the new company. Harry H. Siert is treasurer of the producing company, and B. H. Harper, secretary.

Merriam said the organizing of the new company should eliminate much of the confusion concerning Northern's production.

"The Federal Power Commission has jurisdiction over our pipe line system, but does not have over our production," said Merriam. "This has caused confusion in our applications to the commission."

Northern's president said a separate company for producing properties should help the situation as Northern's new subsidiary could then be treated like any other producer.

Northern also notified the commission of the formation of the new producing company and that the gas reserves remain committed to this new construction through gas purchase contracts.

Petroleum Transportation Portrayed in Shell Film

"Oil—The Invisible Traveler," a new color motion picture portraying all aspects of petroleum transportation, is ready for free distribution to schools and other educational institutions, Shell Oil Company has announced.

The 20-minute, 16 mm sound film explains by live action and animation how the oil industry performs the herculean task of moving more than 300,000,000 gal of petroleum and petroleum products a day from oil well to consumer. The new film is the fourth in Shell's educational series, "This is Oil," which the company has produced to give an easy-to-understand demonstration of the basic operations of the oil industry.

To facilitate classroom use of the motion pictures in the "This is Oil" series, Shell has developed special teachers' manuals and wall charts.

The company welcomes requests for its motion picture catalogue listing all titles. Address: Shell Oil Company, Room 501, 1008 West Sixth Street, Los Angeles 17, California.

Humberstone Elected Vice President of AWS

J. H. Humberstone, vice president of the Air Reduction Company, Inc., has been elected second vice president of the American Welding Society, and took office at the 33rd annual meeting of the Society at Philadelphia, Pennsylvania, recently.

Humberstone was graduated from Ohio State University with the degree of Bachelor of metallurgical engineering in 1931. After being associated with General Electric Company for several years as an electrode development engineer, he transferred to the Arcrods Corporation at the time of its formation.

Upon returning from his wartime assignment as a research supervisor of the War Metallurgy Committee, Humberstone became director of research and welding engineering for the Arcrods Corporation, in which capacity he served until early in 1946, when he was appointed vice president in charge of operations.

Gas Gathering System Proposed

The Fort Worth Basin Gas Company, organized by O. R. Smith and associates of Fort Worth, Texas, proposes construction of a gas gathering system with main line extending from near Brownwood, Brown County, Texas, into Grayson County, Texas, which system will gather gas from 32 or more counties.

Gasoline plants will be a part of the system with three initial plants in Brown, Parker, and Grayson counties.

This system is planned for a wholesale distribution of gas and gas products to gas distributing systems on a national scale, as well as to ultimately serve the Fort Worth and Dallas industrial area, which is rapidly expanding. It is given as an opinion by the organizers of the company that the Fort Worth basin in time will prove to be one of the largest gas reserves left in this country. Scattered and unheralded drilling within the last year is beginning to prove up this area and change the geological and petroleum engineering thinking that has prevailed in the past.

The system is to be owned and financed as a cooperative organization of independent oil operators and eastern finance companies, the major portion of the capital being supplied by Texas operators and financiers.

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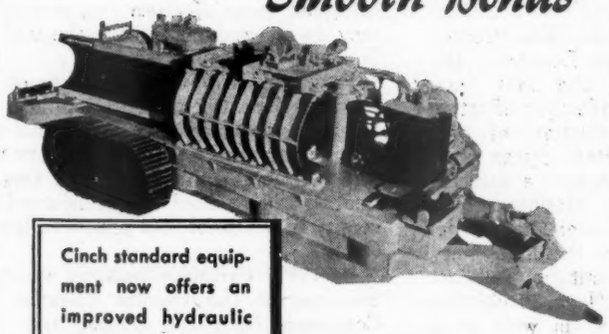

Cinch standard equipment now offers an improved hydraulic system and new wedge-type pin-up slide for greater durability and speed. If desired, even faster, easier maneuvering can be obtained with Athey tracks and hydraulic lift tongue.

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Pipe Line Personals

J. K. Horton, president, Pacific Public Service Company, San Francisco, California, has been elected a director of the American Gas Association to succeed **Ernest G. Lawson,** former president of the Pacific Coast holding company, who resigned. Horton is a native of Nebraska and was graduated from Stanford University in 1936. He began his business career with the Shell Oil Company and attended night law school. He was admitted to the California Bar in 1941 and began the practice of law in San Francisco.

He joined the Coast Counties Gas and Electric Company, in November, 1944, as secretary and legal counsel. In March, 1951, he was elected executive vice president of Coast Counties Gas and Electric Company and Pacific Public Service Company. He is presently chairman of the board of Coast Counties Gas and Electric Company, and president of Pacific Public Service Company, its parent company.

Charles S. Mitchell has been elected vice president of Cities Service Oil Company (Delaware), according to an announcement by **S. B. Irelan,** president of the company, following a meeting of the board of directors held in Bartlesville, Oklahoma. Mitchell is a member of the board of directors of Cities Service Oil Company and president of Cities Service Pipe Line Company. He has been connected with Cities Service since 1930 when he joined the company as a junior engineer. Prior to his election as president of the pipe line company, he was manager of the Crude Oil Supply and Transportation Division of Cities Service Oil Company, a position he still holds.

M. A. Wilson, Jr., of Bartlesville, Oklahoma, has been named representative of Cities Service Oil Company's crude purchases and sales department for the state of New Mexico, according to an announcement by **C. S. Mitchell,** manager of the company's Crude Oil Supply and Transportation Division. Wilson has his headquarters at Roswell. He joined Cities Service in 1948 after graduating from the University of Missouri with a degree in journalism. He was originally assigned to the Industrial Relations Department at Bartlesville and later was transferred to the Crude Purchases and Sales Department. He served in Bartlesville until early in 1951, when he was transferred to the department's Midland, Texas, office. He has been in armed forces service since July of 1951.

Gordon Lefebvre, president of The Cooper-Bessemer Corporation, was re-elected chairman of the manufacturers section of the American Gas Association at its 34th annual convention held in Atlantic City, New Jersey.

As president and general manager of The Cooper-Bessemer Corporation, Lefebvre has been closely associated with the complex needs of America's natural gas industry. Coincidental to activities with the AGA have come many noteworthy developments in gas engines and compressors by his company and other major equipment builders that serve this field.

A graduate of Virginia Polytechnic Institute, Lefebvre attended the United States Military Academy at West Point. Following an apprenticeship at the Norfolk and Western Railroad, he became affiliated with E. I. DuPont de Nemours and Company. In 1919, he joined the General Motors Corporation and was placed in charge of production at the Chevrolet plants under William Knudsen. Elected vice president in charge of General Motor's activities in Canada, he later returned to the United States to take charge of the corporation's Pontiac division. Prior to joining The

Gordon Lefebvre

Cooper-Bessemer Corporation, he was associated with the American Locomotive Corporation and responsible for its diesel engine division.

A member of the Joint War Production Committee of the Economic Defense Board during the last war, Lefebvre devoted considerable effort to coordinating the production of war materials in the United States with those of Canada. He is now a director of the Diesel Engine Manufacturer's Association and is a member of the executive committee of the Machinery and Allied Products Institute. He is active in the Society of Naval Architects and Marine Engineers, as well as a member of the American Society of Mechanical Engineers.

The manufacturer's section of AGA considers all matters relating to machinery used in the production and transmission of gas. It also has jurisdiction over exhibitions and considers matters regarding the design and manufacture of gas appliances.

James L. Parmelee has been appointed manager of Northern Natural Gas Company's new Area Development Department, it was announced by **Larry Shomaker,** vice president of the company. Shomaker said the new department was created to assist in the development of industry, agriculture, and natural resources in the area served by the company.

James L. Parmelee

"Natural gas has become such an important factor in area growth that the company believes it should have a specialized department to assist any development program which would help the communities served by Northern," Shomaker said.

The department will make studies of the potentialities of the area and develop programs aimed toward assisting state and local organizations interested in community growth.

"We feel that there is a definite need for specialized groups to augment the work now being done by local and state development organizations," said Shomaker. "Northern is constantly assembling new information throughout its area for market demand studies. The company believes that through this new department much valuable information pertaining both to fuels and other factors essential to progress can be channeled to interested parties."

He said the department will cooperate with local and state Chambers of Commerce and such groups as the Committee of '52. Smaller cities, which are also attracting many industries, Shomaker said, can especially use this service as they do not ordinarily have the staff or facilities to do such work.

Parmelee is well qualified to direct the new department as he has had extensive experience both in the natural gas industry and Chamber of Commerce work. He was graduated from Omaha Central High School and Creighton University Law School, and practiced law in Omaha.

In 1927, Parmelee became assistant manager of the Omaha Chamber of Commerce Industrial Bureau and took an active part in the Omaha Industrial Development Corporation. Later he served as secretary of Chambers in Shenandoah and Marshalltown, Iowa.

He joined Northern in 1931 to work on franchises in Nebraska, Iowa, South Dakota, and Minnesota. From 1936 until 1950 he worked for the company in Amarillo, Texas, on acquisitions of oil and gas leases and other gas production problems.

In 1950 he returned to Omaha as manager of the exploration division. He recently has been active in the company's negotiations for a gas supply in Canada.

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Pipe Line Personals

Glenn J. Frisinger, veteran telegraph operator for Service Pipe Line Company, has been promoted to chief of wire communications. He succeeded **E. A. Price** who retired after 35 years' service with the company. **Ray H. Warlick** was promoted to Frisinger's former position of assistant wire chief.

Frisinger started his telegraphy career at the age of 10 as an apprentice operator for the Erie Railroad in Indiana. At 13 he was a full-time telegrapher for the Erie. He worked for the railroad in Indiana and Ohio four years. In 1914 he resigned and came to Tulsa.

For three years he was employed as a telegrapher for the Prairie Pipe Line Company, and on February 1, 1917, joined the organization that later became Service Pipe Line Company. He has had continuous service with the company, all of it in Tulsa, and in 1936 was promoted to assistant wire chief.

Warlick worked for Western Union 24 years, five of them in Tulsa. During that time he held the position of telegrapher, office manager, and assistant wire chief. He joined the Telephone and Telegraph department of Service Pipe Line Company in 1948.

Service Pipe Line Company's wire communication facilities extend through 10 of the 11 states in which the company operates. Its 13,500 channel miles of lines follow the pipe line right-of-way on the company's private facilities, or on leased poles, from New Mexico and the Gulf Coast to Chicago. Private wires serve the Rocky Mountain line running from Freeman, Missouri, through Wyoming almost to the Montana state line. In addition, the company operates widespread shortwave radio facilities.

Glenn J. Frisinger

Ray H. Warlick

Facilities have not yet been extended to the Williston Basin of North Dakota where the company operates a large gathering system.

R. P. Dougherty, formerly general superintendent for Wyco Pipe Line Company with headquarters in Denver, Colorado, recently accepted a position as general superintendent of the Triangle Pipeline Company at Shreveport, Louisiana.

A. E. Hass, Cities Service Pipe Line Company, Bartlesville, Oklahoma, is a new member of The Pipe Liners Club of Tulsa. Other new members are: **W. L. Kline,** Cities Service Pipe Line Company, Cushing, Oklahoma; **Marvin C. Jones,** Mid-Continent Pipe Line Company, Tulsa, Oklahoma; **Harold D. Wright,** Pure Transportation Company, Tulsa, and **C. L. Bernard,** Pure Transportation Company, Tulsa.

G. H. McKay, consulting engineer on gas and petroleum matters, announces he has moved his offices to 1033 San Jacinto Building, Houston, Texas. The telephone number is Charter 1402.

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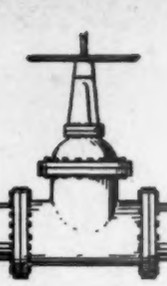
PIPE LINE PROJECTS



Northern Natural to Begin New Construction

Northern Natural Gas Company plans to start construction of new facilities immediately with hopes of increasing the capacity of its pipe line system 20,000,000 cu ft a day by the first of the year. This will be in addition to the 40,000,000 cu ft of gas Northern made available to its customers on October 6.

John Merriam, president of the company, said this construction, when completed, will make more natural gas available to all local gas utilities served by Northern. Good construction weather will be necessary, he said.

He also said the company plans to continue construction of new facilities so that by next summer an additional 90,000,000 cu ft of natural gas will be made available. This would increase the company's capacity to 825,000,000 cu ft a day. Part of the new construction program was completed last year when the company increased its capacity from 600,000,000 to 675,000,000 cu ft a day. Cost of the entire construction program will be approximately $70,000,000.

Northern received a modified order from the Federal Power Commission in November authorizing the new construction. Northern notified the commission that it has directed its contractors to begin construction of the new facilities as soon as they can move necessary equipment to construction sites.

In the telegram to the commission the company pointed out that it still believes one of the conditions in the modified order is beyond the commission's powers, and that it will start construction without waiver or prejudice to any of its rights to contest the order.

The paragraph questioned by Northern outlines the conditions under which the company could or could not alienate, transfer, or sell its reserves.

Temporary Authorization Given Southern Natural

The Federal Power Commission has granted temporary authorization to Southern Natural Gas Company, of Birmingham, Alabama, to operate certain pipe line facilities, construction of which previously was approved by a temporary certificate, and to install additional natural gas facilities to meet customer requirements.

The facilities covered by the temporary certificate are part of a project proposed by Southern to increase the daily delivery capacity of its pipe line system from 670,000,000 cu ft to 1,020,000,000 cu ft of natural gas. A portion of the overall application already has received final FPC approval, and the remainder, including those facilities covered by the temporary certificate, is still pending before the commission.

The commission on August 29, 1952, granted temporary authorization to Southern for the construction of 87.8 miles of 24-in. loop lines and 4.7 miles of 14-in. loop line, to provide additional capacity of 40,000,000 cu ft a day. Estimated cost of this construction is $5,233,600. The August 29 temporary certificate, however, did not authorize operation of the facilities.

On November 3, 1952, Southern requested a temporary certificate authorizing the operation of these facilities, and also the construction of additional facilities. The company said that the facilities covered by the August 29 temporary authorization are needed to meet peak day firm gas delivery obligations in the 1952-53 winter.

The additional facilities to be built by Southern under the new temporary certificate include about 16 miles of loop line and a submarine crossing of the Etowah River, and will enable the company to meet firm hourly requirements of its customers, particularly those of Atlanta Gas Light Company. Estimated cost of these facilities is $895,900.

The commission's temporary authorization is conditioned to require the deliveries from the new facilities be limited to existing authorized customers. The FPC said that its action "is without prejudice to such disposition of the application for a certificate as the record may require."

East Tennessee Granted Authority for Construction

The Federal Power Commission has authorized East Tennessee Natural Gas Company, of Knoxville, Tennessee, to construct a 100-mile extension of its natural gas transmission system, from a point near Knoxville to the Kingsport, Tennessee, area, together with approximately 58 miles of various sized lateral lines.

The project, estimated to cost approximately $5,800,000, will provide natural gas service to Morristown, Johnson City, Elizabethton, Bristol, Greeneville, and Kingsport, all in Tennessee. The authorization is conditioned, however, to require East Tennessee to file appropriate evidence of franchise authorization for gas distribution in Greeneville and Kingsport prior to the commencement of construction of the project.

The authorization also is conditioned to require East Tennessee to submit a plan of financing prior to the start of construction and within 90 days of the issuance of the certificate, and to file a rate schedule satisfactory to the FPC not less than 60 days prior to the commencement of service.

Permit Granted for $32,518,500 Construction

The Federal Power Commission has authorized Southern Natural Gas Company, of Birmingham, Alabama, to construct pipe line facilities, estimated to cost $32,518,500, to bring natural gas from 12 fields in southern Louisiana and southern Mississippi.

The new facilities will include more than 326 miles of pipe line and approximately 8700-hp in compressor capacity. These facilities are part of a project proposed by Southern to increase the daily delivery capacity of its system from 670,000,000 cu ft to 1,020,000,000 cu ft.

The facilities authorized by the FPC include: (1) a 67.8-mile, 24-in. line extending southerly from the company's Gwinville, Mississippi, compressor station to a point called Franklinton Junction, Louisiana, together with a 19-mile 8-in. lateral line extending easterly to the Sandy Hook field, Mississippi; (2) 109.5 miles of 20-in. line extending southwest from Franklinton Junction to the Duck Lake Gas field, Louisiana, thence 12.7 miles of 10-in. pipe line to the Lake Sand field, Louisiana; (3) 117.6 miles of 20-in. line extending southeast from Franklinton Junction to a point in Plaquemines Parish, Louisiana, together with lateral lines to various fields in Louisiana; (4) a new 3300-hp compressor station on the 117.6-mile line; and (5) additions of 5400-hp at the company's Gwinville station.

The delivery capacity of the pipe line from Franklinton to Gwinville will be 298,700,000 cu ft a day.

The commission conditioned its authorization to require that the construction be completed and operations begin by January 1, 1954. The commission specified that the facilities are not to be used to serve any of the new markets proposed by the company in its application for the entire project.

Cities Service Gas to Add 11,400 Horsepower

The Federal Power Commission has authorized Cities Service Gas Company, of Oklahoma City, Oklahoma, to install a total of 11,400 hp at one existing and one new compressor station on the company's gas pipe line system in Kansas.

The project, estimated to cost $2,781,000, includes construction of three 1600-hp units at Cities Service's Greensburg compressor station in Kiowa County, and six 1100-hp units at a compressor station to be situated in Harvey County.

Construction of the facilities will increase the capacity of the company's 26-in. line from the Kansas-Hugoton gas field to Kansas City, Missouri, by 56,000,000 cu ft of gas a day.

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Pipe Line Projects

Temporary Approval For Compressor Station

Arkansas Louisiana Gas Company, of Shreveport, Louisiana, has been granted temporary authorization by the Federal Power Commission for the construction and operation of a 7500-hp natural gas compressor station in Clark County, Arkansas.

The station, estimated to cost $2,147,470, is designed to make available substantially greater volumes of gas to existing customers of Arkansas Louisiana in central Arkansas. The station will be connected to the company's "Line S," which extends from Waskom, Texas, to Perla, Arkansas. Arkansas Louisiana said that installation of the station will reduce peak day curtailments in Arkansas by about 40,000,000 cu ft a day.

Continental Purchases Louisiana Pipe Line

Continental Pipe Line Company, a subsidiary of Continental Oil Company, has announced the purchase of a 27-mile 4-in. crude oil pipe line in Louisiana from Sunray Coastal Pipe Line Company.

The line extends from Longville in Louisiana's Beauregard Parish directly south to Lake Charles. Beginning December 31, it will be used by Continental to transport crude oil from fields in the Longville area to Conoco's Lake Charles refinery, which is currently undergoing a $27,000,000 expansion program.

FPC Denies Proposal for Texas-Ohio Gas Pipe Line

The Federal Power Commission has denied applications by Texas-Ohio Gas Company, of Houston, Texas, for authority to construct a 1406-mile pipe line extending from Texas to Ohio and to import natural gas from Mexico.

The commission found that the company "has failed on this record to show that the proposed service, construction, or operation is or will be required by the present or future public convenience and necessity."

The pipe line, estimated to cost $185,000,000, would have extended from the U. S.-Mexican border in Hidalgo County, Texas, to a terminus near Lancaster, Ohio. Texas-Ohio planned to sell all of its gas to Reserve Natural Gas Company, a newly-formed corporation, at the Ohio terminus of the line. On a 95 per cent load factor basis, Texas-Ohio would require 480,000,000 cu ft of gas per average delivery day, plus 32,000,000 cu ft for fuel gas and line loss, or a total of 512,000,000 cu ft daily.

Texas-Ohio proposed to procure about 232,000,000 cu ft of this gas from Mexico, 173,000,000 cu ft from gasoline plants, and 107,000,000 cu ft from gas fields in Texas. The company had submitted a proposed contract—which was never executed—with Petroleos Mexicanos, containing a provision that Texas-Ohio must obtain an FPC certificate by July 31, 1952, and begin construction by September 15, 1952.

Texas-Ohio submitted no gas reserve or deliverability estimates in support of its gasoline plant gas commitment, and only 18,200,000 cu ft of the proposed field gas purchases were covered by the form of purchase contracts usually submitted by applicants in certificate matters, FPC states.

The commission said that considering this lack of showing of an adequate supply of gas, taken together with the nebulous state of evidence as to whom and in what volumes Reserve Natural intends to sell the gas, the lack of evidence as to the ability of Reserve Natural to absorb and pay for the 480,000,000 cu ft of gas for 365 days in the year, and the lack of evidence as to economic feasibility of the proposed project, it concluded that Texas-Ohio "has not sustained the burden of showing that it is 'able and willing properly to do the acts and perform the service proposed'."

Proposed oil products pipe line from Billings, Montana, to Spokane, Washington.

Continental to Construct 600-Mile Products Line

Plans for construction by Continental Pipe Line Company of a 600-mile, 8-in. oil products pipe line from Billings, Montana, to Spokane, Washington, were announced by W. L. Kygar, president. Continental Pipe Line Company is a subsidiary of Continental Oil Company.

Starting at Billings, the line will extend westward to Bozeman, Helena, and Missoula, Montana, cross northern Idaho, and on to Spokane. Terminals will be situated to serve the western part of Montana, parts of Idaho, and eastern Washington. The line will have an ultimate capacity of 25,000 bbl of oil products a day.

It is expected that construction of the line will begin as soon as government approval can be obtained for pipe and materials, and completion of certain negotiations that are now under way, said Kygar. It is contemplated that the line will be named the Yellowstone Pipe Line, he added.

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Philco Microwave equipment is designed for utmost reliability, flexibility and ease of maintenance... qualities demanded without compromise by the Armed Forces. Philco's ability to surpass these rigid standards provided the Armed Forces with an immediate source of vital communications equipment.

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Gas Line from Middle East to Europe Held Sound

A 2500-mile international super-inch pipe line, transmitting natural gas from the Middle East to Paris and other consuming centers in Europe, is economically and commercially sound, according to a preliminary report, entitled "Natural Gas Supply for Europe," made public by S. D. Bechtel, president of Bechtel Corporation and chief executive officer of the world-wide Bechtel engineering and construction organization.

The Bechtel organization, with major offices in New York, San Francisco and Los Angeles, has engineered or constructed more than 9000 miles of crude oil and gas pipe lines in the United States, Canada, the Middle East, and South America.

"The rehabilitation of Europe," the report states, "has emphasized that area's present and future needs for a greatly increased supply of fuel to reestablish and economically expand its diversified economy on a firm foundation."

Natural gas from Iraq, Iran, Kuwait, and Saudi Arabia could be delivered in large volumes to most consuming centers of fuel-short Europe at a lower cost than present solid fuel prices and at a material saving below present manufactured prices—in many instances for less than half of the present cost of coal or oil, the report states.

A pipe line making available a natural gas supply for Europe, in its initial step costing approximately $425,000,000, according to the report, could be completed in three years, provided the right-of-way and necessary construction materials could be obtained.

Based upon experiences in other parts of the world, the report suggests that the standards of living in Europe will be raised wherever an abundant supply of low-cost fuel can be provided for broadening the base of industry, increasing the number of jobs, reducing production costs, and supplying a source of heat not now available to the average citizen.

This preliminary report was completed in March, 1951, by a group of Bechtel International Corporation engineers under the leadership of Earl F. English, vice president. Bechtel International Corporation is a subsidiary of Bechtel Corporation. The report has been made public at this time, according to Bechtel, in response to requests from "those who see the far-reaching potentialities of this modern peaceful means for balancing some of the world's resources and promoting the general welfare."

The political obstacles are recognized, but the report states "that they may be overcome because of the many benefits which can be realized by all countries."

Noting that the ultimate supply of natural gas to all Europe undoubtedly would require very large pipe line capacity, the report assumes that the natural gas line system would be developed in steps. The initial step, consisting of one 2500-mile super-inch pipe line, delivering 500,000,000 cu ft of gas a day, would cost approximately $425,000,000. The second step, a parallel super-inch pipe line delivering an additional 500,000,000 cu ft of gas a day, would cost only $350,000,000, due to various savings that would be incurred in the second or subsequent steps.

The proposed route from the Middle East to France would run from Kirkuk in Iraq across Turkey, under the Bosporus between Asia and Europe near Istanbul, and then proceed through northern Greece to Yugoslavia and Trieste. From there, it would cut across northern Italy, go through the Alps to Austria, southern Germany, and on to Paris. Branch laterals some 300 miles in length would connect the industrial centers of Europe with the trunkline operation.

Such a trunkline, built for the first 1800 miles with 34-in. and 36-in. diam pipe and for the last 700 miles with 24-in. and 26-in. pipe, would require about 15 compressor stations to transmit and deliver 500,000,000 cu ft of gas a day.

Annual operating cost, without allowing for any taxes or profits, is estimated at approximately $34,000,000 for the initial stage. This would amount to an average transmission cost per 1000 cu ft along the main trunkline of 22 cents. Based on the assumption of an initial field purchase price for the natural gas of 3 cents, a total delivered cost per 1000 cu ft on the main line is estimated at 25 cents. In addition, the branch line transmission cost is estimated at 7 cents per will be 1000 cu ft, thereby giving a delivered cost throughout Europe ranging between 25 and 32 cents per 1000 cu ft.

Based on the preliminary studies, it appears possible that natural gas could be delivered in Europe at figures ranging from 30 cents to 50 cents per million Btus for industrial heating purposes. In contrast, solid fuel costs in leading European centers, such as Berlin, Brussels, and Paris, are in excess of 65 cents per million Btus under favorable conditions and "probably much higher for domestic use." The cost of manufacturing gas in Paris, the report states, "is in excess of $1.00 per 1000 cu ft of 1000 Btu gas as compared to a possible delivered cost of natural gas of less than 50 cents."

Referring to potential markets, this preliminary report notes that, whereas the total population of Europe exceeds 330,000,000 as contrasted with approximately 150,000,000 in the United States, the total average supply of both manufactured and natural gas in Europe was only 5 cu ft per day per person in 1949, as contrasted with a daily use of natural gas the same year in the United States of 77 cu ft per day per person. "It is probable that Europe, with a population over twice as great, might develop a similar market."

In response to the practical question as to when this Trans-European gas pipe line would be built, Bechtel stated that the Bechtel organization is continuing its studies. He further observed that, when the peoples of Europe really want the advantages to be gained by having available a large supply of low-cost fuel, the gas pipe line system will be built.

Trans Mountain to Extend Line Into United States

Trans Mountain Oil Pipe Line Company plans to build a super-inch pipe line extension across the Canadian and United States border from a point near Sumas, British Columbia, toward Seattle with a lateral connecting with the new General Petroleum refinery at Ferndale, north of Bellingham, Washington. Robert L. Bridges, president of Trans Mountain, has announced.

Currently, Trans Mountain is constructing a 711-mile, $86,000,000 crude oil pipe line from Edmonton, Alberta, to Vancouver on the Pacific Coast. This will be completed in August of next year and Alberta oil should reach the Pacific Coast in October. The General Petroleum Corporation refinery at Ferndale will have a capacity of 35,000 bbl per day and will cost approximately $35,000,000. It is being designed to utilize Redwater crude shipped through Trans Mountain from Alberta.

The pipe line extension will cost approximately $2,750,000, Bridges indicated. Furthermore, it will be constructed during 1953 so that it will be ready for operation when General Petroleum's refinery is completed in 1954.

Plans for the southward extension call for a 24-in. pipe line for a distance of four miles within Canada and 14 additional miles in the State of Washington. The line will run southwest from Sumas, toward Seattle. A 12-mile 16-in. lateral will be laid from a point near Laurel, Washington, to the Puget Sound location of the new proposed General Petroleum refinery near Ferndale, 12 miles northwest of Bellingham.

Port Arthur-Baton Rouge Products Line Announced

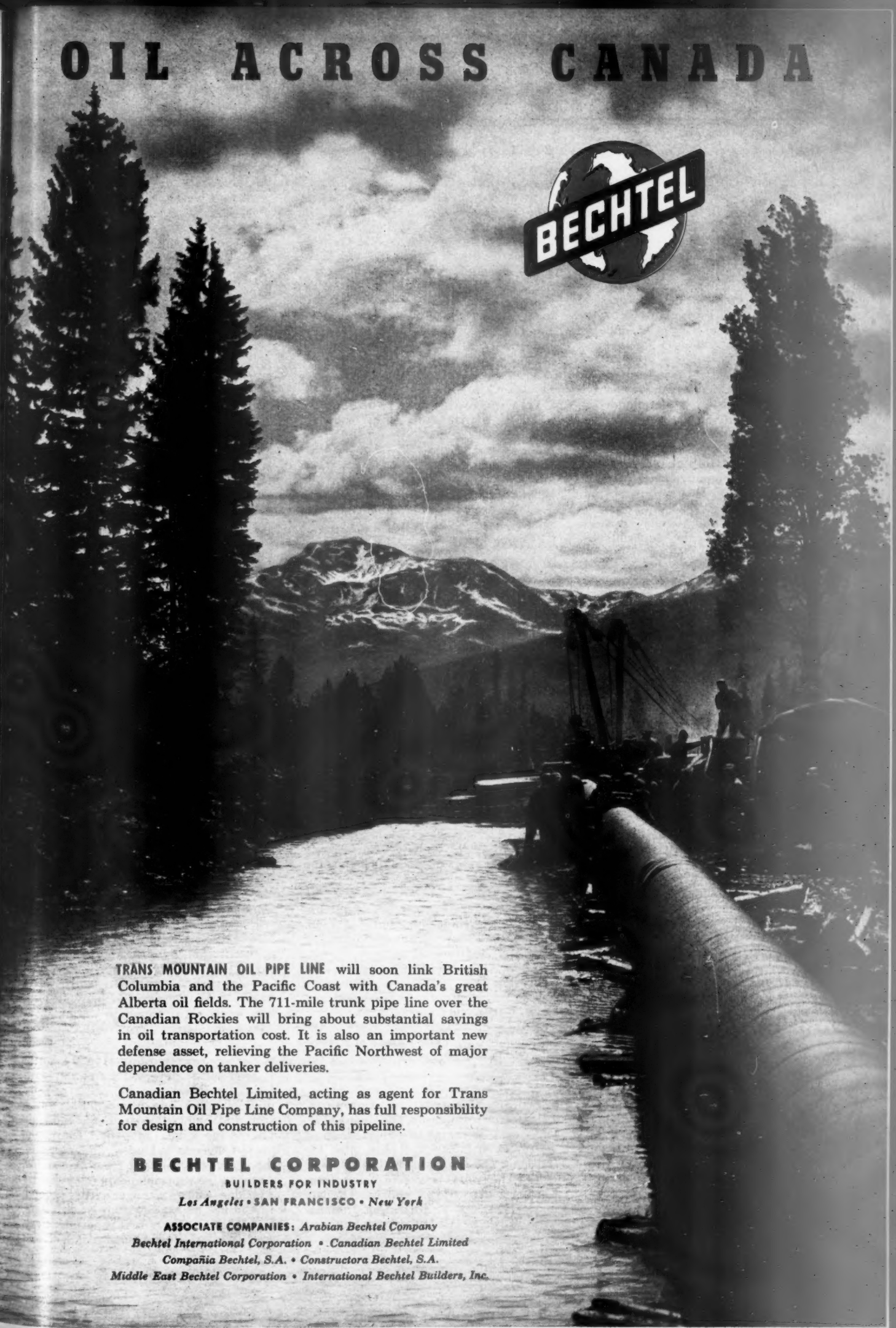
Plans have been announced for the construction of a 16-in. diam refined products pipe line between Port Arthur, Texas, and Baton Rouge, Louisiana, to be known as the Evangeline Products System.

The system will be owned on an undivided interest basis by The Texas Pipe Line Company, 40 per cent; Gulf Refining Company, 40 per cent; and Sinclair Pipe Line Company, 20 per cent. The Texas Pipe Line Company, on behalf of all interests, will construct the system.

Construction began the middle of November on pumping stations near The Texas Company's and Gulf Refining Company's refineries at Port Arthur and near the Cities Service Company's refinery at Lake Charles. Line pipe is expected early in 1953, and it is anticipated that the project will be completed and in operation in the early summer of next year.

The initial capacity will be 96,000 bbl a day, and the line will transport gasoline, kerosine, and fuel oil.

OIL ACROSS CANADA



TRANS MOUNTAIN OIL PIPE LINE will soon link British Columbia and the Pacific Coast with Canada's great Alberta oil fields. The 711-mile trunk pipe line over the Canadian Rockies will bring about substantial savings in oil transportation cost. It is also an important new defense asset, relieving the Pacific Northwest of major dependence on tanker deliveries.

Canadian Bechtel Limited, acting as agent for Trans Mountain Oil Pipe Line Company, has full responsibility for design and construction of this pipeline.

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With the PIPE LINE CONTRACTORS

Houston Contracting Company, 2707 Ferndale Place, Houston, Texas, has the following construction work under contract:

Approximately 190 miles of 24-in. crude oil line for Rancho Pipe Line Company from a point west of Austin, Texas, to Shell Oil Company's Deer Park refinery near Pasadena, Texas. Oklahoma Pipe Line Constructors (joint venture) has completed its 64-mile section from Deer Park west to the Brazos River. Houston Contracting Company began laying pipe on its 126-mile section from the Brazos River near Sealy, Texas, west to Austin, Texas, on November 1. E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager. Headquarters are at Columbus, Texas.

Approximately 6½ miles of 16-in. natural gas line for Tennessee Gas Transmission Company near Grand Chenier, Louisiana. This is a marsh job with the spread having headquarters on a quarter boat in the vicinity of Rollover Bayou. H. L. Leake, superintendent; S. B. Harrison, assistant superintendent; H. C. MacWhinnie, field office manager. Land headquarters are at Abbeville, Louisiana.

Western Pipe Coating Company, Inc., P. O. Box 181, Iola, Kansas, is coating 144 miles of 8⅝-in. pipe on the Salt Lake Pipe Line Company job between Juniper and Glenns Ferry, Idaho. H. W. Carey is superintendent of the spread between Juniper and Burley and R. O. Sinclair office manager. On the spread between Burley and Glenns Ferry, Cecil Carey is superintendent, C. W. Doyle foreman, and R. O. Sinclair office manager. The prime contractor for this work is Engineers Limited Pipe Line Company.

On the Sinclair Pipe Line Company project from Evanston to Green River, Wyoming, 95 miles of 8⅝-in. pipe is being coated for the prime contractor, Engineers Limited Pipe Line Company. C. M. Vaughan is superintendent and Chester C. Hall foreman.

Sparling-Davis Company, Ltd., 7310 99th Street, Edmonton, Alberta, Canada, is finishing up a 20-in. river crossing near Outlook, Saskatchewan, for Interprovincial Pipe Line Company. Headquarters are in the Outlook Hotel. J. C. Williams is superintendent, Tex Eubanks assistant day superintendent, Dick Pence assistant night superintendent, and Bob Foster welding foreman.

Work has just begun on a river crossing near Kamloops, British Columbia, on the Trans Mountain Oil Pipe Line Company system, sub-contracted from Mannix, Ltd. The address is P. O. Box 337, Kamloops. D. R. Hibbs is dredge superintendent, Cliff Poole foreman, Don Stokes ditch foreman, and T. McLoud right-of-way foreman. This crossing is of 24-in. pipe.

Comstock Midwestern, Ltd., 206 Laird Drive N. Leaside, Ontario, Canada, has been at work since late in May on 472 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, which will extend from Edmonton, Alberta, to Vancouver, British Columbia. The central project office is at 3390 Kingsway, Vancouver. The telephone number is Dexter 5511. C. C. Bledsoe is project manager, Charles Rathgeb, Jr., assistant project manager, M. T. "Bill" Wilhite general superintendent, A. T. Tolbert assistant superintendent, and Mike Seville office manager.

The three spreads are located as follows:

Jasper, Alberta: John Work spreadman, D. E. Anderson office manager, and Herb Allen master mechanic.

Valemount, British Columbia: Doyle Crittendon superintendent, T. E. Hoskins assistant superintendent, and N. O. Boies office manager.

Chilliwack, British Columbia: Herschel Howard, superintendent; Charline C. Boies, office manager.

Anderson Brothers Corporation, 6300 Navigation Boulevard, Houston, Texas, began work in November on 22 miles of 10-in. for the Gulf Refining Company from Wortham to Corsicana, Texas, with the field office at the latter point. Bob McGee is spreadman and Dick Bond office manager. Another job for Gulf, 40 miles of 10-in. from Midland to Notrees, Texas, will begin as soon as the above is completed. Bob McGee also will be spreadman on this work. The field office will be at Midland.

The field office for work on the Rancho Pipe Line Company system is now at Fredericksburg, Texas. Aldress Kilgore is superintendent and Russell McDowell office manager. This contract was for the laying of 266 miles of 24-in. from McCamey to Cedar Valley, Texas. There have been interruptions due to pipe shortage.

H. L. Gentry Construction Company, 921 East Michigan Avenue, Jackson, Michigan, is laying an undetermined amount of distribution mains in Toledo, Ohio, for Ohio Fuel Gas Company. The field office is at Perrysburg, Ohio, with Herman A. Stowers superintendent and O. W. Gartin office manager.

A 16-in. crossing is being made on the Maumee River for the Village of Perrysburg. Jim Mitchell is in charge of the work.

Trojan Construction Company, 1416½ North Robinson, Oklahoma City, Oklahoma, is completing the takeup of 400 miles of 8, 10, and 12-in. pipe for the Ohio Oil Company in Indiana and Ohio. The work was contracted from Conyes Construction Company. The last field office was at Rushville, Indiana, with W. E. Deaver superintendent and Palmer Davis office manager.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa, Oklahoma, makes the following construction progress report as of November 14:

Aluminum Ore Company, Bauxite, Arkansas: Process piping, fabrication, 95 per cent completed; installation, 80 per cent completed. Earl S. Powell, superintendent; Morris Garey, office manager, and Ralph Bray, area superintendent.

Sinclair Pipe Line Company, Independence, Kansas: Construct pump station at Quincy, Illinois, 70 per cent completed. Ray M. Johnson, superintendent, and W. D. Kaufman, office manager.

Install piping at Humboldt, Kansas, station, 65 per cent completed. W. E. Taylor, superintendent, and J. A. Stokes, office manager.

Construct pump station at Pontiac, Illinois, 55 per cent completed. Charles Malone, superintendent; Fred Trompler, engineer, and O. L. Westrum, office manager.

Panhandle Eastern Pipe Line Company, Kansas City, Missouri: Erect finfan towers at Pleasant Hill, Illinois, 20 per cent completed. J. M. Graham, superintendent, and R. E. Brewer, office manager.

West Texas Gulf Pipe Line Company: Piping for pumping station at Ranger, Texas, just starting. W. L. Daniel, superintendent, and Lonnie Dorman, office manager.

Reynolds Metals Reduction Plant, Gum Springs, Arkansas: just starting. Sub-contract from Aluminum Constructors Mechanical Trade. K. L. Kreamalmyer, superintendent.

Williams Brothers Company, National Bank of Tulsa Building, Tulsa, Oklahoma, has offices at Atlanta, Georgia (Telephone 47-4341) and Charlotte, North Carolina (Telephone 6-3418). Buddy Franks is general superintendent, Bob Folk and Joe Breedlove office managers, and E. U. Mahaffey and Brownie Young general foremen. The following work is being done:

Distribution lines at Atlanta, Chamblee, and East Point, Georgia.

Distribution lines at Kramerton, Gastonia, and Burlington, North Carolina.

Delivery lines at Thrift, North Carolina, for McCoy Oil Company. Piping for Sinclair Oil Company terminal at Atlanta and Greensboro, North Carolina.

Macco Corporation, 14409 South Paramount Boulevard, Paramount, California, is completing 113 miles of 8-in. products pipe line between Salt Lake City and Snowville, Utah, for the Salt Lake Pipe Line Company. The main project office is at Ogden, Utah. One of the spreads is working from Ogden. Al Anthony is superintendent and L. H. Aldridge office manager. The second spread has its headquarters at Brigham City, Utah. K. W. Sills is superintendent and "Whitey" Jones office manager.

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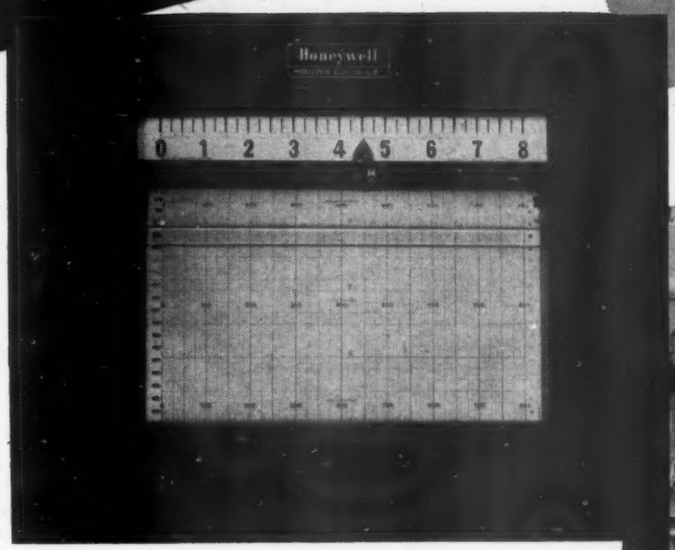
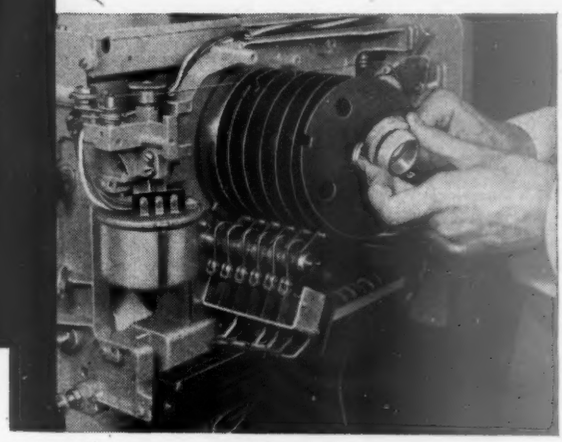


16 temperatures in motors and pumps are concentrated on this ElectroniK Recorder.



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Contractors

H. C. Price Co.—Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 363 miles of 26-in. high pressure natural gas loop lines for Texas Gas Transmission Corporation from the east bank of Mississippi River near Greenville, Mississippi, to Jeffersontown station, Kentucky, a few miles east of Louisville. Spreads are located as follows:

Clarksdale, Mississippi—1724 Ford Street—telephone 2001. C. R. Ice, superintendent; G. A. Harvey, office manager; C. E. Birmingham, equipment foreman; Jesse Cash and W. O. Elliott, right-of-way; E. W. Whisenant, ditch; Forest Loinette, bending; W. T. Dickerson, pipe; L. O. Reutzel, welding; N. D. Adams, coating; J. C. Rich, lower-in, and J. E. Hamilton, cleanup.

Memphis, Tennessee—P. O. Box 7007—Telephone 48-2285: C. E. Shivel, superintendent; D. H. Johnston, office manager; Boyd Danner, equipment foreman; E. D. Worley, road crossing; C. F. Jones and R. H. Edwards, right-of-way; Ray Drewell, ditch; Virgil Huff, bending; R. E. Carriker, pipe; John Stokes, welding; Henry Hill, coating; Bill Buchanan, lower-in, and Paul McCormick, cleanup.

Murray, Kentucky—P. O. Box 190—Telephone 1797: R. L. Ezell, superintendent; W. R. Crego, office manager; Tommy Stammer, equipment foreman; Cleo Robertson, road crossing; J. D. White, right-of-way; W. H. Olrich, ditch; J. H. Latham, bending; Delbert Shivel, pipe; J. H. Riley, welding; J. B. Northcutt, coating; C. W. Sisco, lower-in, and S. L. Price, cleanup.

Princeton, Kentucky — General Delivery—Telephone 2083: G. A. Reutzel, superintendent; W. E. Yount, office manager; J. H. Ingram, equipment foreman; K. N. Adkins, road crossing; J. A. Hairston, right-of-way; Lloyd J. Loncarich, ditch; J. C. Anderson, bending; H. C. Morrison, pipe; R. W. Orr, welding; S. J. Wood, coating; Athel Bell, lower-in; T. E. Walker, cleanup, and Charles Schooler, warehouseman.

Spread Four, under Superintendent Charlie Ice, having finished the work mentioned above move to Anniston, Alabama, during the week of November 10-15 to begin work on a section of 24-in. loop line for the Southern Natural Gas Company. Additional Price spreads will be moved to the Southern Natural project later in the year. H. C. Price Co. and Houston Contracting Company, Ltd., are sharing the construction of 833.4 miles of loop lines for Southern Natural during 1952-53.

H. C. Price Co.—Somastic Division, P. O. Box 1111, Bartlesville, Oklahoma, has the following jobs in progress at its Bustleton, Pennsylvania, plant:

Philadelphia Gas Works Company—Application of Somastic coating to 112,085 ft of pipe ranging in size from 1 to 30 in.

Gulf Oil Corporation—Application of Somastic coating to 52,135 ft of pipe ranging in size from 6 to 24 in. Application of Hevicote to 9300 ft of 8, 12, and 16-in. pipe.

Okonite-Callender Cable Company—Application of Somastic coating to 11,005 ft of 6-in. pipe.

Philadelphia Electric Company—Application of Somastic coating to 92,485 ft of 4 and 8-in. pipe.

South Jersey Gas Company—Application of Somastic coating to 11,319 ft of 8-in. pipe.

C. J. McGonigal — Application of Somastic coating to 2322 ft of pipe ranging in size from 3 to 12- in.

California Oil Company—Application of Somastic coating to 32,103 ft of 8-in. pipe.

W. K. Mitchell Company—Application of Somastic coating to 900 ft of 8-in. pipe.

At the Harvey, Louisiana, plant:

L. E. Farley, Inc. (for Interstate Natural Gas Company, Inc.)—Application of 9/16 in. of Somastic and 1⅝-in. Hevicote to approximately 30 miles of 16-in. pipe.

J. Ray McDermott and Company, Inc. (for Humble Oil and Refining Company)—Application of Hevicote to approximately 14,000 ft of 10¾-in. pipe.

El Paso Natural Gas Company, Bassett Tower, El Paso, Texas, which does its own construction, is laying a 200-mile gathering system in the vicinity of Midland, Texas, pipe sizes ranging from 4-in. through 24-in. The job began the middle of November with the field office at Big Spring. L. A. Davis is spreadman and Bill Shelton office manager.

Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma, began work November 17 on approximately 50 miles of 6-in. through 12-in. for Colorado Interstate Gas Company in the vicinity of Lakin, Kansas. The field office is at Ulysses, Kansas; telephone number 7. Ike Cordell is spreadman and V. L. Bethel office manager.

The city distribution system being installed at Paragould, Arkansas, for Mid-South Gas Company, is approximately one-third completed. This consists of 2, 3, 4, 6, and 8-in. pipe. Laterals, of 3, 4, and 6-in. pipe, from Cotton Plant to Brinkley, from Brinkley to Forrest City, and from Forrest City to Wynne, all in Arkansas, totaling approximately 48 miles, are about half completed. On these jobs Curt Vaughn is general superintendent, J. W. Tyner office manager, Jim Hickman pipe foreman, and Jack Simmons ditch foreman. The field office is at Paragould.

For Kansas-Nebraska Natural Gas Company, 75 miles of pipe is being laid in the vicinity of Julesburg, Colorado, as follows: 30 miles of 8-in., 20 miles of 6-in., and 25 miles of 4-in. This job got underway November 20. Earl Hackleman is spreadman and R. G. Stewart office manager.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, have contracted to lay 75 miles of 12-in. pipe line for Continental Pipe Line Company, from Wichita Falls, Texas, to Duncan, Oklahoma. The field office is at Wichita Falls, with W. L. Boyd superintendent and "Chuck" Siewert office manager. The job is underway.

This contractor also is laying 112 miles of 4-in. through 12-in. pipe between Merino, Colorado, and Gurley, Nebraska, for the Toronto Pipe Line Company. The field office is at Sterling, Colorado. Oscar Phillips is superintendent and Jerry Short office manager.

Sheehan Pipe Line Construction Company, 529 National Bank of Tulsa Building, Tulsa, Oklahoma, is laying 120 miles of 12-in. pipe line in Missouri for the Standard Oil Company of Indiana. Two spreads are in the field. One has its headquarters at Milam where C. M. Brown is superintendent, "Peanut" Kinkaid spreadman, R. L. McElroy office manager. The second spread has its field office at Excelsior Springs. Jim Brown is superintendent and Gerald Burgoon office manager.

An 8-in. crossing is being made of the Kankakee River near Kankakee, Illinois, for Phillips Pipe Line Company. Jim Noland is superintendent and Dean Evans assistant.

Reese Brothers Construction Company, Hugoton, Kansas, is constructing a gathering system for Northern Natural Gas Company, from Guymon, Oklahoma, to Garden City, Kansas, consisting of an undetermined amount of 4-in. through 12-in. pipe. Work has been interrupted by shortage of pipe. Paul G. Reese is superintendent, Edgar H. Reese spreadman, Gale Reese welders foreman, and Frederick Fallert office manager.

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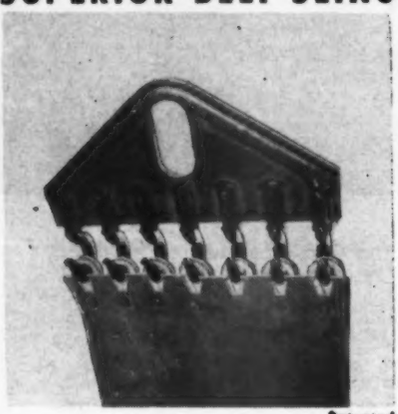

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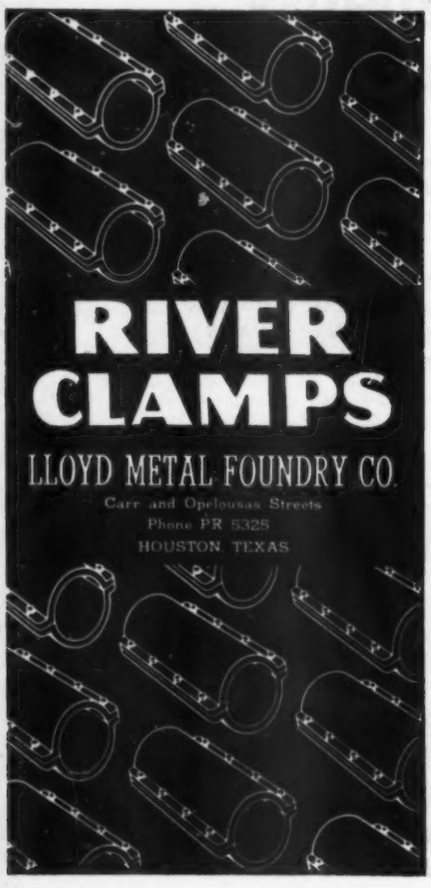


Contractors

Western Construction Company, Hobbs, New Mexico, began laying early in November 52 miles of 12-in. for Continental Pipe Line Company between Oklahoma City and Red River, Oklahoma. The field office is at Norman. M. W. Lasley is superintendent.

Rumsey Brothers Pipe Line Construction Company, 4039 North Broadway, Wichita, Kansas, began work early in November on 20 miles of 12-in. pipe line for Kaw Pipe Line Company between Russell and Susank, Kansas. The field office is at Russell. Dutch Reuther is superintendent and Dusty Rhodes office manager.

Britton Contracting Company, Inc., 93 South Main Street, Washington, Pennsylvania, expects to complete about December 15, 17 miles of 12-in. for the Cumberland and Allegheny Gas Company from Keyser, West Virginia, to Cumberland, Maryland. The field office is at Rawlings, Maryland. Frank Hart is superintendent and Dick Barker office manager.

Brown and Root, Inc., P. O. Box 3, Houston, Texas, plans to begin laying about December 1, 26 miles of 26-in. pipe line for Pan American Pipe Line Company between Genoa and Texas City, Texas.

Panama-Williams Company, 403 Melrose Building, Houston, Texas, is laying 46 miles of 26-in. pipe line for West Texas Gulf Pipe Line Company, from Livingston to Sour Lake, Texas. The field office is at Livingston. Gene Coulter is superintendent and Lloyd Evans office manager. The job got underway the early part of November.

Vaughn and Taylor Construction Company, P. O. Box 1351, Wichita Falls, Texas, is laying a gathering system in the vicinity of Odessa, Texas, for Phillips Petroleum Company that consists of 268 miles of 2-in. through 30-in. pipe. D. D. Vaughn is superintendent and Clark Sayles office manager.

Massey Pipe Line Construction Company, P. O. Box 2099, Corpus Christi, Texas, is taking up approximately 80 miles of 10-in. pipe for Gulf Pipe Line Company between Wortham and Weatherford, Texas. The field office is at Wortham. Buck McIntyre is superintendent and Bob Stiles office manager.

Williams Bros. de Venezuela, S. A., Maracaibo, Venezuela, are making progress on 170 miles of 26-in. being laid for Creole Petroleum Corporation from Ule station on the east side of Lake Maracaibo to Amuay Bay, in Venezuela. Marvin Jones is in charge of the work.

P. & S. Constructors, Inc., Cape Girardeau, Missouri, has under construction for Shell Oil Company, 276 miles of 14-in. pipe between Wood River, Illinois, and East Chicago, Indiana. The field office is at Taylorville, Illinois. A. G. "Arkie" Hobson is superintendent and V. E. Connor office manager.

Harford Brothers Pipe Line Construction Company, Emporium, Pennsylvanian, has laid part of its 75-mile section of 10-in. pipe for Lake Shore Pipe Line Company but has been delayed by the pipe shortage. The section extends from Cochranton, Pennsylvania, to Ashtabula, Ohio, then west to Fairport Harbor, Ohio. The field office is at Geneva, Ohio. Arthur Harford is superintendent and E. L. Summers office manager.

O. R. Burden Construction Corporation, 6702 East 21st Street, Tulsa, Oklahoma, has been awarded the contract to lay approximately 185 miles of 12-in. products pipe line by Standard Oil Company of Indiana between Dubuque, Iowa, and Unionville, Missouri. Work is to begin immediately.

Four spreads are now engaged on the 600 miles of takeup between Drumright, Oklahoma, and Humboldt, Kansas. This is 6, 8, 10, and 12-in. pipe. Ted Price is supervising the spreads working out of Independence and Chanute, Kansas. Paul E. Thibodeaux is superintendent of the spread that has its headquarters at Wynona, Oklahoma, and R. C. Wilkerson is in charge of the Hallett, Oklahoma, spread.

The contractor has three spreads laying pipe for Sinclair between Quincy, Illinois, and East Chicago, Indiana, 210 miles of 22-in. This work is expected to be completed the middle of December. A. B. Haynes is in charge of the spread working from El Paso, Illinois. B. L. Seagle is office manager. Spreads 2 and 3 are working from East Chicago. Fred Byers is general superintendent, Fred Peters and Rube Dodson spread superintendents, and W. M. Clyma office manager.

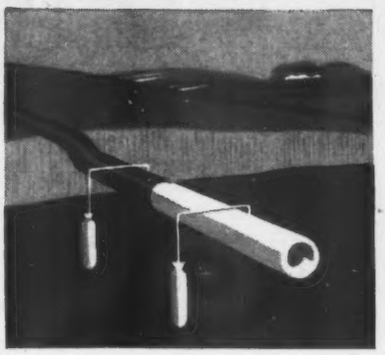
L. E. Farley, Inc., 2609 Sunset Boulevard, Houston, Texas, is waiting on pipe to begin construction of 64 miles of 16-in. pipe line for Interstate Oil Pipe Line Company between Morgan City and Baton Rouge, Louisiana. A field office has been established at Plaquemine, Louisiana. Doc Berton is superintendent and Fred Hudson office manager.

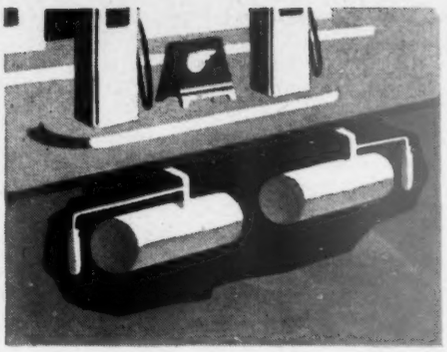
Lone Star Constructors, 10th Floor, Mercantile National Bank Building, Dallas, Texas, has completed the 70 miles of 8 and 10-in. takeup for The Texas Pipe Line Company from Concord station north to Corsicana, Texas. The field office has been at Teague with H. A. Wylie superintendent.

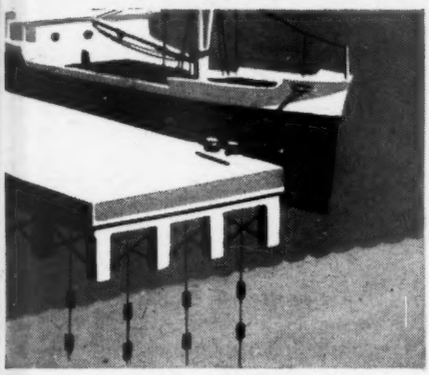
Carl H. Dunn, Burkburnett Building, Fort Worth, Texas, is finishing up 70 miles of takeup work for The Texas Pipe Line Company. The section is between Corsicana and Madisonville, Texas, and consists of 8 and 10-in. pipe. Carl Dunn is in charge personally. The field office is at Streetman.

Missouri Valley Dredging Company, 222 Williams Street, Omaha, Nebraska, is making a 3900-ft, 22-in. crossing of the Illinois River near Havana, Illinois, for the Sinclair Pipe Line Company. Elton Sumrall is superintendent and George Van Horn office manager.

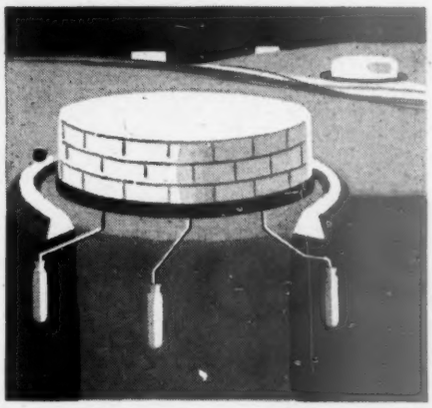
there's one to fit your needs

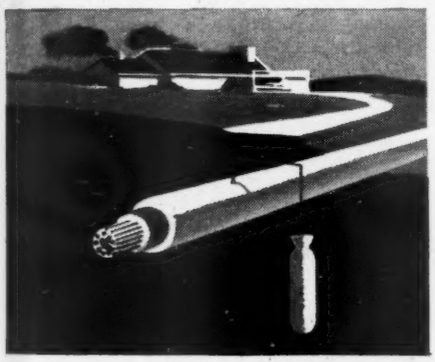


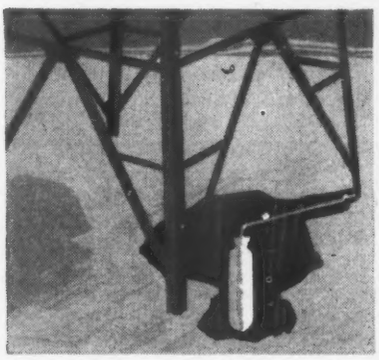


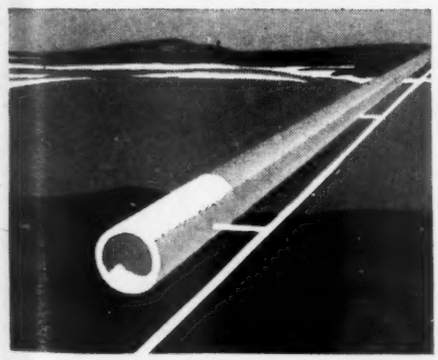


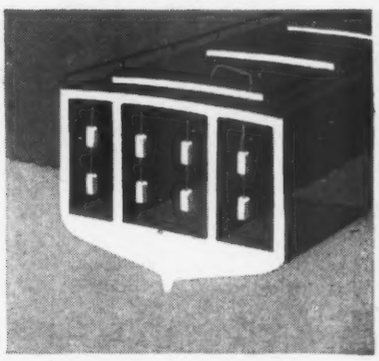
DOW magnesium anodes











Whether underground or under water; whether you require only "hot spot" protection or over-all coverage, or a combination of all you will find there's a DOW MAGNESIUM ANODE designed to solve your particular corrosion problem. Also, investigations show that DOW MAGNESIUM ANODES are both an economical and dependable means of protecting your buried metal structures. In many cases, users have reported that Dow anodes have paid for themselves in less than a year!

The proved effectiveness of Dow anodes is the result of Dow's extensive research and years of experience with magnesium. This knowledge is at your disposal—contact the nearest Dow sales office or one of the Dow magnesium anode distributors listed below for further information on cathodic protection—designed to cut *your* corrosion costs.

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Contractors

Engineers Limited Pipe Line Company, 225 Bush Street, San Francisco, California, is finishing up 220 miles of 8-in. products pipe line for Salt Lake Pipe Line Company, from Snowville, Utah, to Boise, Idaho. The central office is at Twin Falls, Idaho, with Bill Webb in charge. Three spreads have been in operation. At Burley, Idaho, C. E. Hamilton is the superintendent and Harry Culver office manager. At Mountain Home, Idaho, L. E. Robertson is superintendent and Pat O'Toole office manager. At Twin Falls, Idaho, Bill Cook is superintendent and Art Strouse office manager.

Work has begun on 90 miles of 8-in. in Wyoming for Pioneer Pipe Line Company. The field office is at Evanston. Lynn Vassar is superintendent and Harvey Montague office manager.

Anderson Brothers of Venezuela, 6300 Navigation Boulevard, Houston, Texas, is installing 80,000 ft of 26-in. pipe under the Gulf of Coro in Venezuela, South America, for Creole Petroleum Corporation. Earl Saulsman is in charge of the work, with the field office at Las Piedras.

Mary Construction Company, Cape Girardeau, Missouri, began work October 30 on 180 miles of 8-in. pipe line for the Indiana Farm Bureau Cooperative Association, extending from Vernon to Jolietville, Indiana. The field office is at Princeton, with Ganland Mimms superintendent and Lewis Wiist office manager.

Work is in progress also on 51 miles of 14-in. pipe line in Illinois for Shell Oil Company. The field office is at Litchfield. Roy Whitworth is superintendent and Carl Wiist office manager.

Fulton and Brodie Construction Company, P. O. Box 2064, Amarillo, Texas, is completing 76 miles of 20-in. between Wortham and Longview, Texas, for West Texas Gulf Pipe Line Company. The field office is at Tyler. Clyde Peters is spreadman and Hugh Hall office manager.

Williams-Austin Company, Grant Building, Pittsburgh, Pennsylvania, is laying 29 miles of 20-in. pipe for the New York State Natural Gas Company from Tonkin station to Kittanning, Pennsylvania. Ralph Gaddy is superintendent and E. E. Mayes office manager. The job is scheduled for completion about December 15.

Ray L. Smith and Son, Inc., Hazlett Building, El Dorado, Kansas, has completed 20 miles of 30-in. pipe line for Natural Gas Storage Company of Illinois, from Dwight to Herscher. A gathering system and metering station will be completed by December 15. The field office is at Dwight. D. E. Whitworth is superintendent and D. L. Marley office manager.

Seven 12-in. river crossings are being installed for Standard Oil Company (Indiana) on its products system from Sugar Creek Refinery at Kansas City, Missouri, to Dubuque, Iowa. C. O. Taylor and C. Colvin are the superintendents and J. H. Salisbury will be office manager.

Associated Pipe Line Contractors, Inc., 3272 Westheimer Road, Houston, Texas, is taking up 106 miles of 10-in. pipe for The Texas Pipe Line Company from Erath station, Louisiana, west to the Sabine River. The pipe will be reconditioned and used elsewhere. The reconditioning office is at Sulphur, Louisiana, and the field office for the takeup spread at Lake Arthur, Louisiana. J. E. Andrews is superintendent and J. B. Robbins and Ralph Herwig office managers.

Mannix, Ltd., Calgary, Alberta, Canada, has in progress 224 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, extending from Blue River to Coquihalla Pass, British Columbia. The field office is at 412 Victoria Street, Kamloops, British Columbia. C. P. Baker is project manager, "Curley" Wilkerson spreadman, and H. Eisler office manager.

J. L. Cox and Son, Raytown, Missouri, are stringing 340 miles of 22-in. pipe between Salisbury, Missouri, and Shrerville, Indiana, on the Sinclair Pipe Line Company system. Other jobs for Sinclair are 400 miles of 8 and 12-in. from Shannondale station to Wood River station, and 600 miles of 8, 12, and 14-in. pickup from Manuel station, Oklahoma, to Independence, Kansas.

MATHEY PIPE CUTTING AND BEVELING MACHINES

Mathey

LIGHT WEIGHT—CONVENIENT

EASIEST TO INSTALL
Just slip over pipe

QUICKEST IN OPERATION
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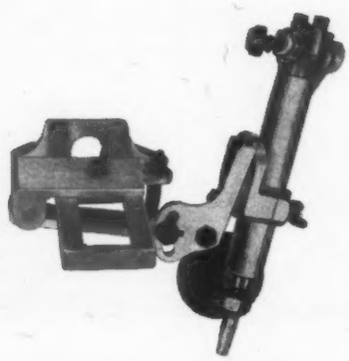
Mathey Pipe Cutting and Beveling Machine. In five sizes for any size pipe from 4" to 36".



Mathey Out-of-Round Attachment. Fits all sizes of machines.

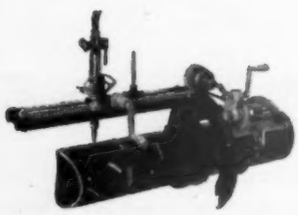


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FIG. 1. Continental Oil Company's new research laboratory at Ponca City, Oklahoma, houses the geophysical, production, and central research laboratories divisions of the development and research department.

Conoco Expands Research

RECENT completion of Continental Oil Company's new research laboratory at Ponca City, Oklahoma, marked the fourth step in the expansion of its research facilities to cover every phase of the scientific and technological interests of a major integrated oil company. Previously completed units were the pilot plant or unit operations laboratory completely equipped with all unit processes required for petroleum refining and petrochemical semi-commercial operation, a fuels and lubricants or "Product Use" testing laboratory equipped for detail study of all forms of lubricants and fuels, and a detergent testing laboratory for the development of detergents synthesized from petroleum products.

The new research laboratory (Fig. 1) is a three-story, reinforced concrete building containing 40,000 sq ft of floor space. The building has no fixed partitions but is fitted with moveable steel sections using a 3 ft 8 in. standard module. The basic laboratory room is 3 by 6 modules or 11 by 22 ft.

The modular design lends itself well to efficient and economical utility distribution. All utilities, including hot, cold and de-ionized water, compressed air, utility vacuum, steam at 15 and 150 psi, and natural gas are distributed in vertical shafts from the roof pent house. The utility mains are taken from the engine room (Fig. 2), in a sub-basement to the pent house (Fig. 3). Every 22 ft on each side of the central hallways, a vertical shaft passes down from the penthouse to the three laboratory floors below. These shafts also carry the hood exhaust ducts and electrical conduit. On each floor, steel doors give access to the utility shaft making repair and change of duty rapid and economical. Fig. 4 shows the manner in which the utilities are distributed to the benches from the utility shafts.

As successful research depends not only on skilled personnel and equipment but also on the availability of supplies and special apparatus, particular attention was given to the planning of the service sections of the new building. Special research apparatus is quickly available from the three service and shop sections. A large glassblowing shop (Fig. 4) is completely equipped for the assembly of complex research glass apparatus including high vacuum equipment. The research machine shop (Fig. 5) is equipped to handle all forms of metal and plastic fabrication. The equipment includes precision lathes, shapers, drills, metal saws, sheet metal forming tools, and electric, and gas welding units.

A well equipped electronic and instrument shop (Fig. 6) makes possible the design and construction of special electronic control and research apparatus. A special shielded laboratory is available for the storage of radioactive isotopes and the preparation of tracer compounds.

The breadth of Continental's interest in research can best be indicated by a brief listing of typical research projects now in progress in the new research center.

The geophysical division of the development and research department is conducting fundamental research on the velocity of and attenuation of audio frequency seismic signals in geological structures. Of more immediate application to field exploration problems are continued development of improved methods of recording, analysis and interpretation of the seismic signals.

Of the many projects under study by the production division, those of particular interest include (1) theoretical studies and practical development of improved instrumentation and interpretation of well logging techniques, (2) improved methods for the examination of formation cores with particular reference to relative permeability, (3) effect

FIG. 2. Engine and utility room, showing centrifugal compressors of air-conditioning equipment in background, and power control panels in foreground.

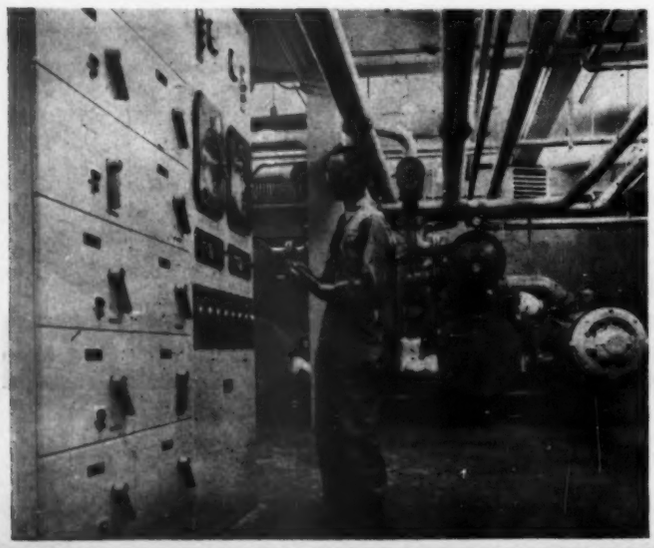

FIG. 3. Utility distribution penthouse on roof has main headers overhead — every 22 ft distribution lines drop vertically to laboratories below.

FIG. 4. Glass lathe in glassblowing shop where all forms of research glass apparatus, including high vacuum equipment are constructed.

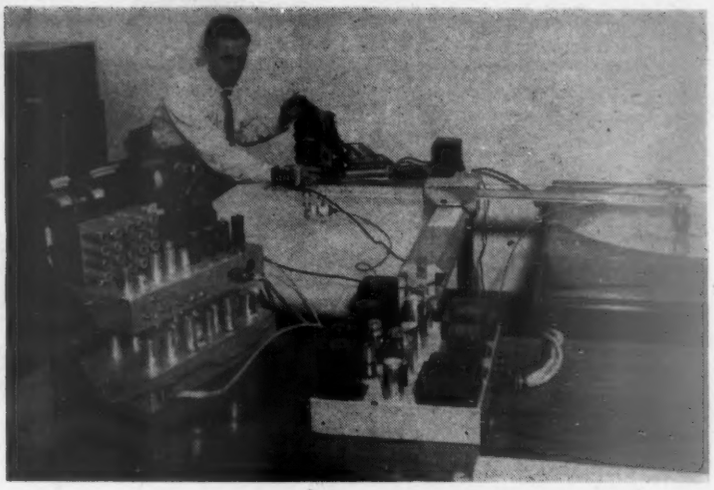

FIG. 6. Electronic laboratory showing newly assembled potentiometric analogue instrument for the study of flow problems in underground reservoirs.

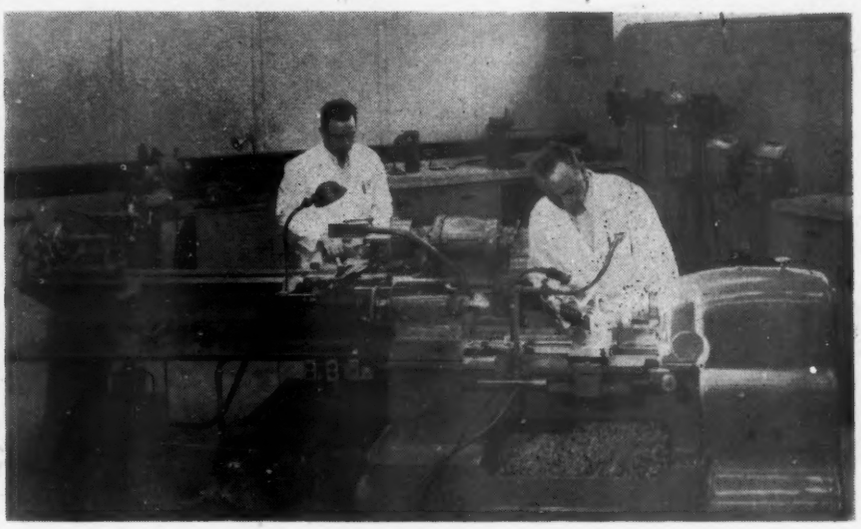

FIG. 5. Research machine shop fully equipped with precision lathes, milling machine, sheet metal forming tools and welding equipment.

of drilling mud composition on oil bearing formations, (4) secondary recovery methods, (5) well completion techniques and both theoretical and practical study of the control of underground corrosion.

The petrochemical section of the organic laboratory is actively engaged in the development of petrochemicals from petroleum raw materials. At present, the major effort is in the field of industrial and domestic detergents (Fig. 7). Continental is now engaged in the commercial synthesis of alkylaryl sulfonatable hydrocarbons from refinery gases and the manufacture of sulfonates and formulated detergents therefrom. Fundamental research in this field includes surface energy studies of detergency and the relation of molecular size and conformation to detergent characteristics. On a broad and long-range basis, active studies are in progress covering the entire range of possible petrochemical activities. * * *

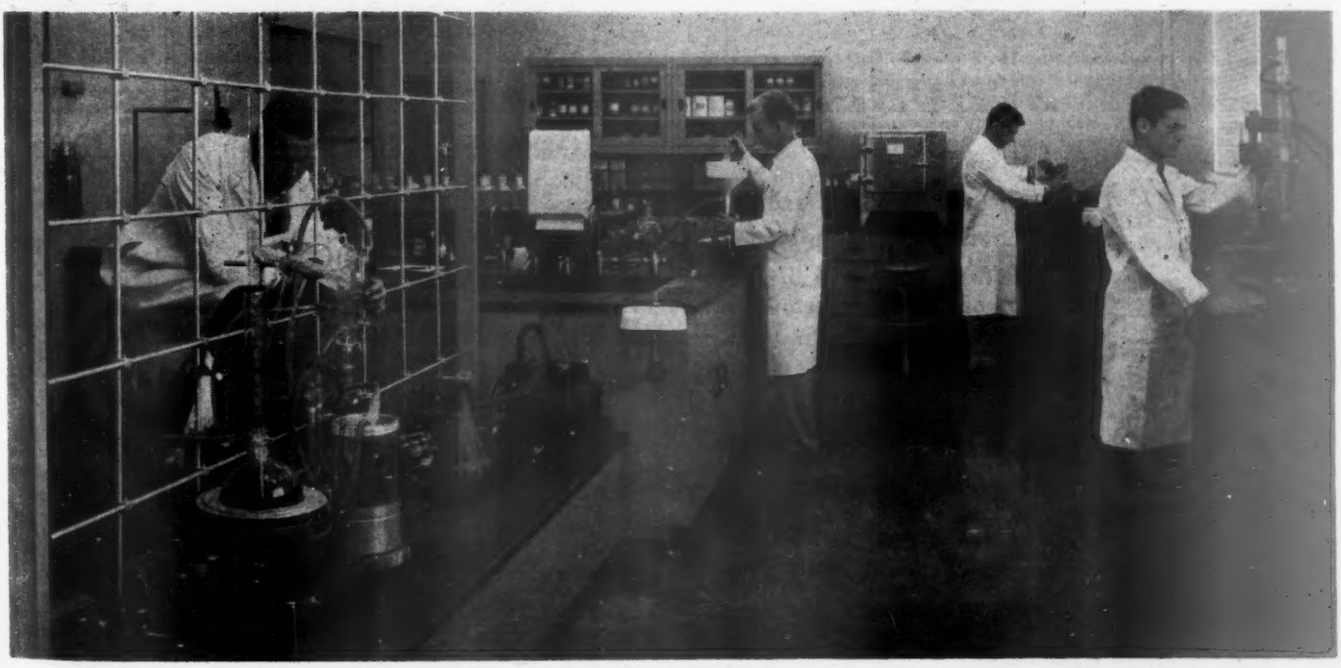

FIG. 7. Typical organic laboratory equipped for synthesis and study of oil and water-soluble detergents and surface active materials.

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132,000,000

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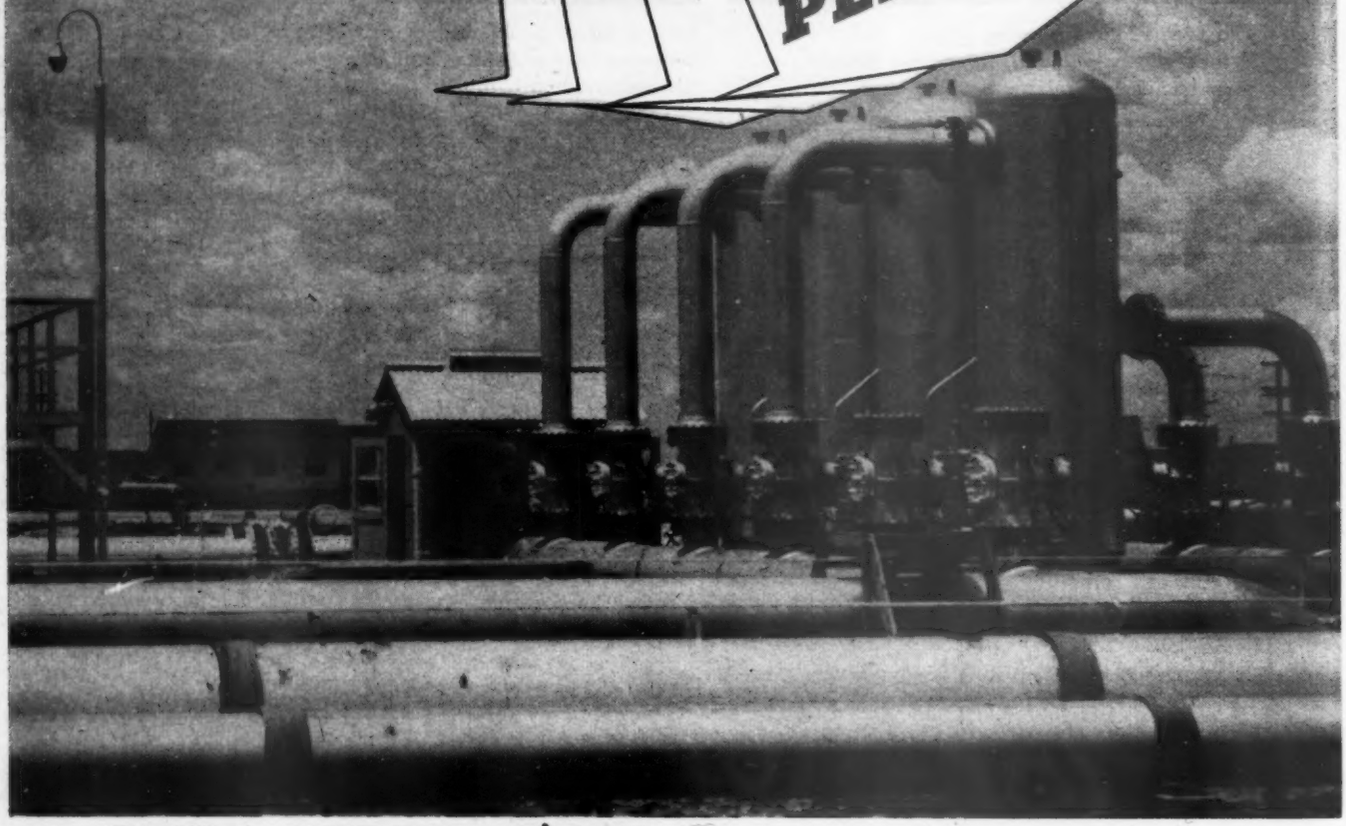

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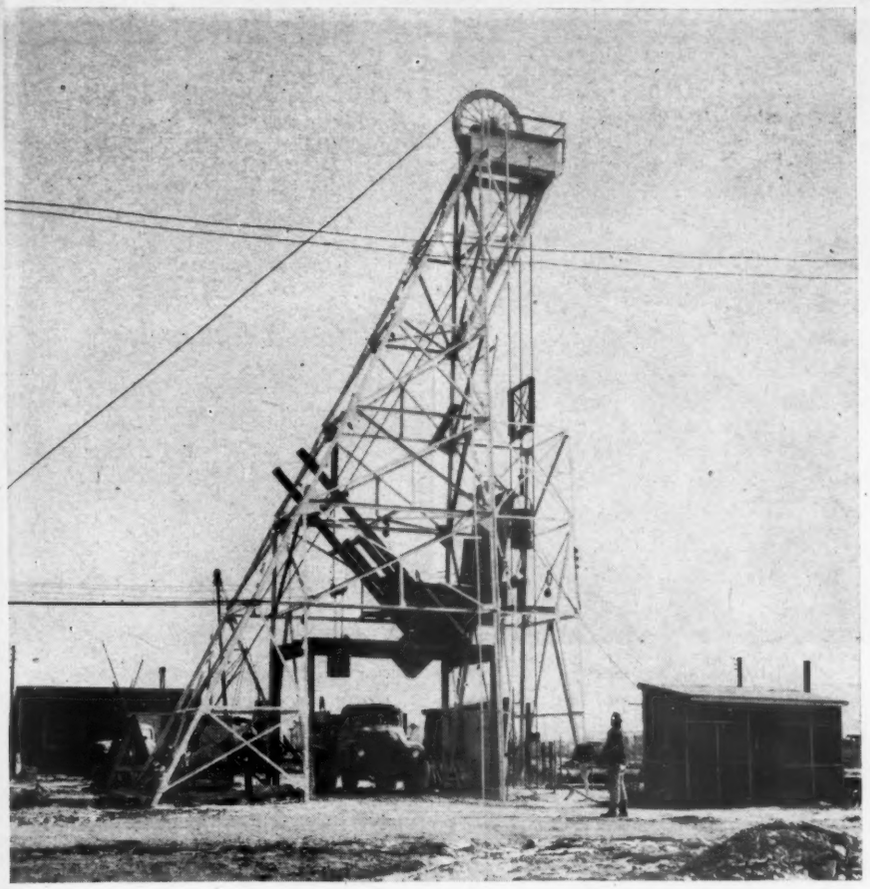

Derrick is used to remove subsurface material from the underground storage project at Kankakee, Illinois, pipe line terminal. Cavern being dug between 200 and 300 ft below earth's surface will be used to store liquefied petroleum gases during summer season for withdrawal in high-demand winter months.

Phillips Prepares Illinois Cavern for Propane Storage

An underground storage cavern now being constructed near Kankakee, Illinois, by Phillips Pipe Line Company, a subsidiary of Phillips Petroleum Company, is expected to be completed about March, 1953.

It is a conventional mining operation being dug in shale between the 200 and 300-ft level. Propane will be fed into the completed cavern by pipe line from Phillips facilities at Borger, Texas, to serve the Chicago and Great Lakes marketing area. The new facilities will store propane in the slack summer season, for distribution during the heavy-demand winter months. Seasonal peak loads on production facilities will thus be leveled out and much waste eliminated.

Phillips also has in operation two underground caverns near the company's manufacturing facilities at Borger in the Texas Panhandle. These sealed caverns are 1500 ft below the surface in salt formations. Each has a capacity of approximately 50,000 bbl.

Other locations for underground storage caverns are under study by Phillips at points near large consuming centers. Phillips is in position to move liquefied petroleum gas through its products pipe line systems to the Great Lakes and Rocky Mountain regions and intermediate points.

Phillips pioneered the sales market development of liquefied petroleum gases (propane and butane) and is now the largest supplier of these products, sold under the trade name Philgas. The post-war demand for these versatile gases has been steadily growing at an unprecedented rate. In addition to the long-standing conventional uses for household cooking, heating, industrial fuels, and public utility gas, large volumes are being consumed as motor fuels for tractors, trucks, and buses.

5 reasons WHY

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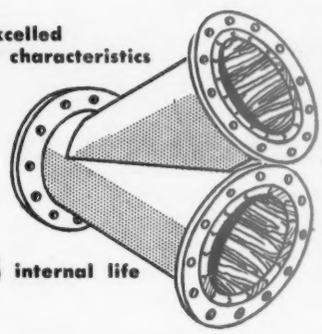
2 Unexcelled flow characteristics



3 Long internal life

4 Unexcelled cushioning capacity against pulsations, vibrations and other mechanical influences

5 Low cost

Combines the strength of steel with the durability of wood. Recommended for salt water lines, desalting service, dilute caustic soda and polysulfide transport, acid wastes, cooling tower service and oil gathering lines. Operating service up to 250 p.s.i. and 180°F. Higher pressure ratings for special service requirements. All pipe flanged and available in 10′ and 20′ standard lengths or custom fabricated to specifications. Diameters 4″ thru 48″. Easy to cut and re-flange. All flanges have standard ASME bolt circle.

Wood-lined fittings in standard and special designs for all diameters. For catalog and additional information, write Dept. PE.

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Manufacturers of Wood-Stave, Saran Rubber-Lined, Stainless Steel and Monel Piping

Operator examining the bottom hole pattern after drilling with 1¼-in. diameter microbit.

Machinist here is milling teeth on an experimental bit cone.

Instrument to observe and to photograph microstructure of specimens at magnifications between 50 and 1500.

Research and Engineering Laboratory Opens

Used tools of yesterday are studied today so that the equipment of tomorrow will be better in every respect

Operator just starting a drilling test drilling on a hard formation. Tests of this nature are made to determine the best conditions to use in drilling hard formations so that the best results can be obtained with the rock bits.

THE opening of the new Hughes Research and Engineering Laboratory marks the 42nd year that the Hughes Tool Company has been engaged in research to advance rotary drilling.

From the standpoint of facilities, the laboratory is regarded as the finest of its kind in the world devoted exclusively to the drilling industry. Six laboratory sections, complete within themselves, and a modern machine shop are housed in the laboratory building which occupies a site adjacent to the company's manufacturing plant in Houston.

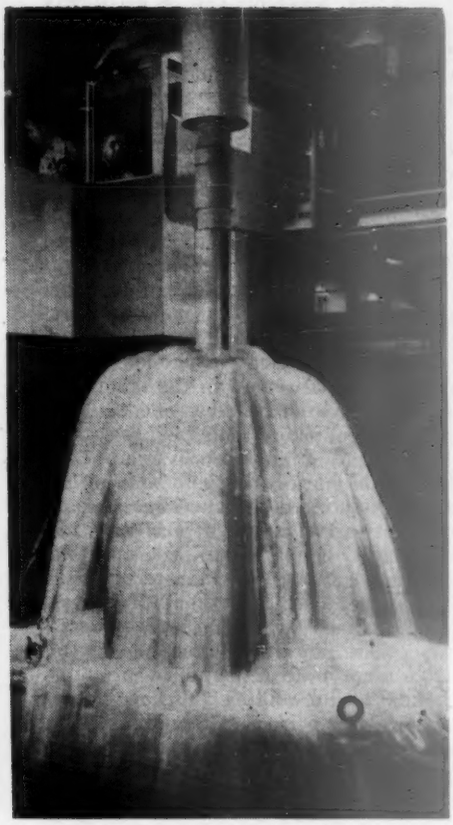
The laboratory building is a brick and stone structure, 325 ft long and 120 ft deep, with a two-story center section. The total floor area is approximately 60,000 sq ft.

Space is provided in the two-story section of the laboratory building for chemical, spectro-chemical, and metallographic laboratories, staff offices, library facilities, projection, conference, and smaller specialized rooms.

A field-size drilling rig is situated within the left rear corner of the building. The drilling rig house, with its roof at the same level as the shop area roof, appears from the outside to be architecturally integral with the main building. This corner of the building is actually a cutaway section, however.

Built by Hughes Tool Company in 1911 this is the first rock bit laboratory in the oil industry. The derrick and shed contained a hydraulic machine and other equipment for observing the cutting action of bits.

A special test set up to observe the action of various type of water courses in rock bits. The pressure drop across the bit and the impact velocity of the drilling fluid are important for proper operation of a jet bit.



Drilling tests in progress. The rock bit has drilled into the surface of the test rock and is making hole. The drilling fluid, water in this case, is removing the cuttings from the hole as they are drilled by the rock bit.

The 118-ft derrick rises approximately 90 ft above the roof of the building. The substructure, or cellar, is situated at ground level about 15 ft beneath the rotary or working floor of the derrick, which, in this case, is the ceiling of the laboratory. This area serves as the laboratory work room in which drilling actually takes place, and in which the operator is able to observe and measure the performance of bits undergoing tests.

Variable drilling loads as high as 100,000 lb can be applied by a hydraulic pulldown yoke attached to the drillstem just above the rotary table, located between the ceiling of the laboratory and roof of the building. Rotational speeds up to 400 rpm can be used in the drilling tests.

In addition to the big drilling rig, and situated in the same area of the laboratory, is a smaller auxiliary rig, regarded sentimentally by Hughes personnel. It was first used by Howard R. Hughes, Sr., when he inaugurated rock bit research in 1910. The rig, leased at that time and purchased in 1917, has been rebuilt many times. It is far from a museum piece, however. The rig is regularly used in drilling operations that do not require the capacity and versatility of the larger unit.

A microbit, 1¼ in. in diameter, is used by Hughes engineers to drill cores and rock samples from areas in which adequate data concerning performance of standard-size bits are lacking. The performance of the microbit in these cores and rock samples makes it possible to estimate the performance of full-size bits in the same type of rock formation.

The chemical laboratory is fully equipped to handle a wide variety of analytical procedures related to metals. Among the laboratory's specialized equipment is a direct reading spectrometer, one of the most remarkable instruments of its kind in use by industry. It is capable of simultaneously determining eight elements and handling 200 sam-

Plans are formulated by members of Hughes Tool. Shown here are: Lyle Payne, assistant vice president engineering; F. L. Scott, director of research; Paul Reeve, manager of Engineering Administrative Division; D. J. Martin, vice president engineering; F. H. Berleth, director of engineering training, and R. W. Schlumpf, chief metallurgist.

ples a day. Elements can be accurately determined by this equipment in a matter of minutes where days would be required for the same analysis by other methods.

The laboratory is equipped with heat treating, carburizing, and atmosphere control furnaces for use in the production of new test models and for setting up and maintaining proper controls over metallurgical operations employed in the Hughes manufacturing plant.

Induction melting units are available to produce experimental melts of abrasion-resistant alloys and other metals.

Magnetic particle inspection equipment has been set up in the laboratory for examination of test models and regular production tools.

The welding laboratory is equipped to handle the hard facing and welding operations required on experimental tools, conduct investigations of new hard facing materials and techniques, and pilot the control work on materials and equipment used in shop production welding, hard facing and brazing operations. An important function of this laboratory is the development of quality standards for welding and hard facing materials and process standards for the applying of these materials to Hughes products.

Laboratory instruments in the metallographic laboratory include the latest type hardness testers and equipment used in carrying on microstructural studies of extremely hard materials (the diamond substitute types). The laboratory also includes a unique macro-etching installation, designed by the Hughes metals group, together with extensive photographic equipment and dark room.

A high speed motion picture camera, capable of taking pictures at speeds of 3000 frames per minute, is frequently employed in photographing rock bit drilling action.

Testing of product parts and product assemblies is the primary concern of the mechanical testing section of the laboratory and the project engineers assigned to this work. Many of the test machines used are designed by the group to approximate the conditions that will be imposed on the part or assembly in actual service.

Mechanical testing equipment includes a high capacity torque measuring machine, machines for fatigue testing full-size drill stem connections, machines to test resistance to abrasion, and machines designed and built to test antifriction bearings and plain bearings under variable loading and rotational speeds while being flushed with an abrasive-ladened fluid to simulate drilling mud.

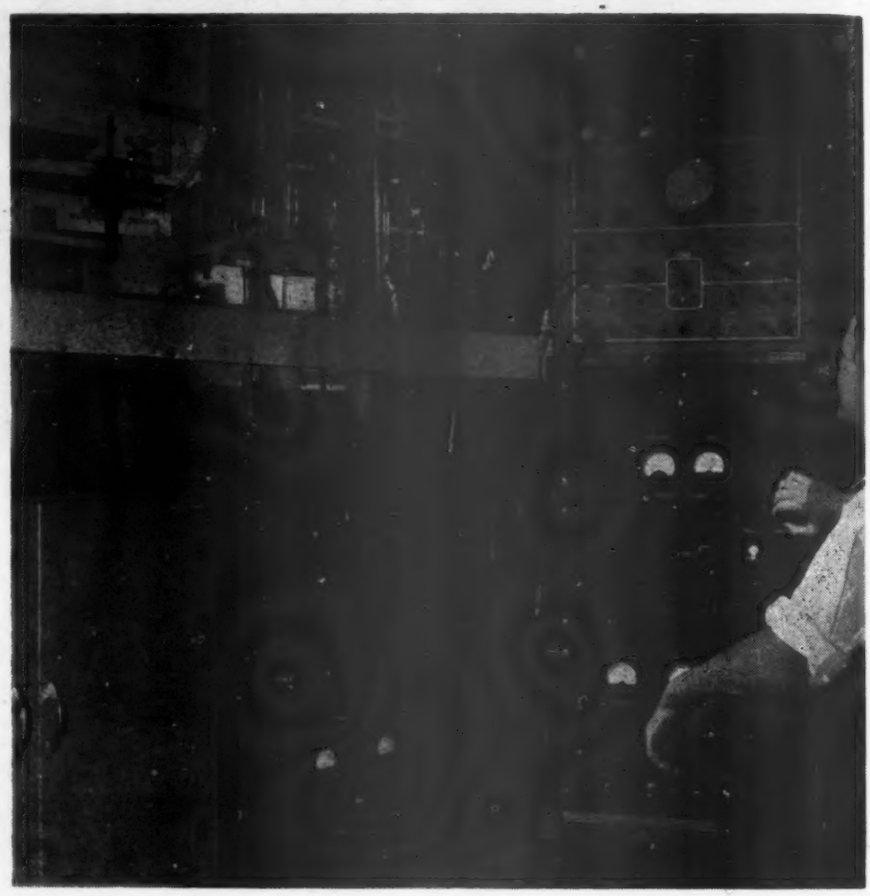
The objective of these specialized tests is to determine the materials and designs that will improve the performance and service life of the product.

Reporting to D. J. Martin, vice president—engineering, three engineering departments are responsible for the research, design, and development work involved in the manufacture of the products of the Hughes Tool Company. These departments include research engineering under F. L. Scott—research director, product engineering under L. L. Payne—assistant vice president—engineering, and metallurgical engineering under R. W. Schlumpf—chief metallurgist. The Hughes Tool Company research and engineering laboratory functions as a division of the metallurgical department. Heading this division is W. R. White—laboratory directory.

The laboratory organization is divided into groups or units, each of which handles a particular classification of work under a group supervisor. At the present time, these groups are as follows:

1. Specialized mechanical and physical testing operations.
2. Metals group, responsible for conventional type physical testing, heat treating, melting, metallography, and photography.
3. Chemical laboratory.
4. Welding laboratory.
5. Machine shop.

In addition to the group supervisors the organization includes several project engineers who are assigned to the supervision of the detailed work involved in major individual projects or investigations. * * *



Microwave spectrometer.

LOOKING INTO MOLECULES

The most fundamental of all questions in the physical world is: What is the structure of matter? Amazing strides have been made toward understanding the arrangement and behavior of atoms in molecules and towards a fuller explanation of what lies within the atom, yet, only a beginning has been made by comparison with what remains unknown.

Progress, however, is being registered. One of the newest and most valuable tools is an outgrowth of radar. It is called microwave spectroscopy. It is a means for investigating one aspect of molecular structure—the rotation of complex molecule—that hitherto has defied experimental study and which is virtually impossible to calculate. With the microwave spectrometer energy at precisely known frequencies (to one part in a million) from a klystron is passed down a waveguide filled with the substance in question. The amounts of energy absorbed at different wavelengths are registered as sharp lines on oscilloscope screens. From these absorption spectra, a physicist can determine the nature of the spin of atoms in complex molecules.

The equipment and techniques are new. Only a beginning is being made with them. Last year the methyl alcohol molecule, which is the lightest and simplest molecule capable of internal rotation, was analyzed. The instrument is being "tuned up" for studies of other, more difficult ones. The results so far are simply lines on a spectrum chart. Abstruse, you say! So was Einstein's pronouncement in 1903, that has since led to the release and control of nuclear energy.

NGAA Prepares Standards for Underground LP-Gas Storage†

Basic safety rules for building, testing, and fitting installations are set up

THE NATURAL GASOLINE ASSOCIATION OF AMERICA has been preparing liquefied petroleum gas test methods, specifications, and plant procedures for 22 years, having begun its activities in this field in 1930.

As a result of the recent trend toward the use of underground storage wells (usually washed out of salt) and underground storage caverns (usually mined out of suitable shale or limestone formations) for the bulk storage of liquid petroleum products, particularly LP-Gases, it seemed proper that NGAA should, because of member company experience in this new activity, develop certain basic safety standards for the construction, testing, and fitting of these underground LP-Gas storage installations.

It is to be understood that since geological formations may and do vary widely, good engineering may dictate certain modifications of these standards.

DIVISION 1

LP-Gas Underground Storage Wells

1. Location of LP-Gas Underground storage wells.

a. LP-Gas underground storage wells shall be located a minimum distance of 100 ft from nearest line of adjoining property which may be built upon — measured from the wellhead (christmas tree). Reasonable care and precaution shall be exercised to prevent any unplanned communication of well with any existing cavern or mine.

1.2 Construction of LP-Gas underground storage wells.

a. LP-Gas underground storage wells shall be drilled and completed in accordance with the rules, regulations, or practice pertaining to oil or gas wells of comparable depth applicable to the same area in which they are located. In case no regulations exist, good oil field practice shall be followed. It is recommended that where practical the casing be cemented from bottom to top, however, in no case shall the casing be cemented less than 200 ft above the salt formation.

1.3 Wellhead, valves, and fittings.

a. Christmas tree (wellhead fittings) shall be of steel.

b. Valves shall be flanged valves and shall have an ASA primary service pressure rating of not less than 300 psig (Series 30).

c. If stored LP-Gas is to be withdrawn by pumping, the tubing equipment such as stuffing boxes, oil savers, flow tees, and other fittings shall have a working pressure of not less than 250 psig.

d. Casing valves and fittings shall have a minimum ASA pressure rating in accordance with the following table.

Tubing length	Steel valves ASA rating	Steel casing heads and steel tubing heads* API psig working pressure	API flange series No.
0—1500....	300	720	300
1501—2000....	400	960	400
2001—3000....	600	960	400
3001—5000....	900	2000	600
5001—7500....	1500	3000	900

* This table will apply to steel valves if API ratings are used.

1.4 Maximum design pressure of LP-Gas underground storage well.

a. Maximum design and operating pressure of an LP-Gas underground storage well shall not exceed one psig per foot of overburden, e.g., if well ceiling is 500 ft below the surface, the maximum design and operating pressure would not exceed 500 psig. The geological character of the overburden may further limit the permissible operating pressure.

1.5 Vapor pressure‡ limitation on LP-Gas to be stored.

a. Vapor pressure of LP-Gas to be stored shall not exceed the maximum design and operating pressure of the LP-Gas underground storage well. Vapor pressure shall be determined at the maximum well temperature.

1.6 Pressure test of completed LP-Gas underground storage well.

a. Upon completion of an LP-Gas underground storage well and prior to LP-Gas injection for storage, a hydrostatic test, equivalent to the vapor pressure of the material (vapor pressure obtained at the storage temperature) to be stored, plus one hundred psig, shall be applied, measured at the casing head.

b. The test shall be deemed successful if the shut-in pressure remains constant for one hour after fluid in hole has reached equilibrium.

1.7 Protection of christmas tree (wellhead) fittings.

a. Where local conditions dictate, the christmas tree shall be protected from mechanical damage.

1.8 Operation of LP-Gas underground storage well.

a. These wells may use (but not be limited to) either water displacement or pumping methods to withdraw or recover the LP-Gas.

DIVISION 2

LP-Gas Underground Storage Caverns (Mined or Natural)

2.1 Location of LP-Gas underground storage caverns.

a. LP-Gas underground storage caverns shall be located a minimum distance of 100 ft from line of adjoining property which may be built upon — measured from christmas tree (fittings atop cavern shaft).

b. Cavern extremities shall be located a minimum distance of 50 feet from line of adjoining property which may be built upon.

c. Reasonable care and precaution shall be exercised to prevent any unplanned communication of cavern with any existing cavern or mine.

2.2 Maximum design pressure of LP-Gas underground storage cavern.

a. Maximum design and operating pressure of an LP-Gas underground storage cavern shall not exceed one psig per foot of overburden, e.g., if cavern ceiling is 200 ft below the surface, the maximum design and operating pressure would not exceed 200 psig. The geological character of the overburden may further limit the permissible operating pressure.

2.3 Vapor pressure limitation on LP-gas to be stored.

a. Vapor pressure of LP-Gas to be stored shall not exceed the maximum design and operating pressure of the LP-Gas underground storage cavern. The vapor pressure shall be determined at the maximum cavern temperature (approximately 60-65 F).

2.4 Cavern valves, pipings, and fittings.

a. The valves, pipings, and fittings shall be of steel and shall be suitable for a minimum working pressure of 250 psig.

2.5 Pressure test of completed LP-Gas underground storage cavern.

a. Upon completion of an LP-Gas underground storage cavern and prior to LP-Gas injection for storage, an air test of 100 psig shall be applied.

b. Test shall be deemed successful if shut-in pressure remains constant for 12 hr after reaching equilibrium.

2.6 Protection of christmas tree fittings (atop cavern shaft head).

a. Where local conditions dictate, the christmas tree shall be protected from mechanical damage.

2.7 Operation of LP-Gas underground storage cavern.

a. These caverns may use (but not be limited to) either gas displacement or pumping methods to withdraw or recover the LP-Gas. * * *

†Adopted as tentative standards, August 1952, by the Natural Gasoline Association of America, 422 Kennedy Building, Tulsa 3, Oklahoma.

‡As determined by NGAA LPG Vapor Pressure Test.

Oil Men Believe Outlook For Industry Better

Oil men greeted news of the overwhelming Republican victory with hopes that a new party in government will prove a better climate in which the oil industry may grow. With the prospect of less federal government control plus fair treatment from this body, lower taxes, restoration of states rights, and the virtual certainty that state ownership of the tidelands will be re-affirmed, the oil industry as a whole has expressed the opinion that it will be easier to meet all needs of the oil-consuming citizenry.

On April 30 the Defense Production Act will go out of existence and it is not likely the new president will renew it. This will lift controls on prices and wages, and allocations of materials, except in military and defense orders.

Frank M. Porter, president, API, declared in Chicago recently that two oil agencies, the Petroleum Administration for Defense, and the National Petroleum Council should be continued.

The "so called oil cartel" grand jury will have to vote an indictment before Attorney General McGranery leaves in January if the investigations of the seven oil companies should continue. If an indictment is voted, many oil men believe it unlikely the case will even be tried.

The tidelands is the only thing definite the president-elect has committed himself on so far as oil is concerned. He has given his promise to sign a bill quitclaiming title to submerged lands with the three-mile limit for all states except Texas, where it will be 10½ miles.

API 1953 Officers Named

L. S. Wescoat, president of Pure Oil, and Frank M. Porter, president of Fain-Porter Drilling were re-elected, respectively, chairman of the board and president of the American Petroleum Institute.

Vice presidents elected were: Division of Transportation, P. C. Spencer, president of Sinclair, re-elected; Division of Production, John G. Pew, vice president, Sun Oil; Division of Refining, John G. Newton, vice president, Magnolia; Division of Marketing, Robert M. Bartlett, vice president, Gulf; B. Brewster Jennings, president of Socony-Vacuum, re-elected treasurer, and Lacey Walker, re-elected secretary and assistant treasurer.

Newly elected directors include: Z. K. Brinkerhoff, Jr., Brinkerhoff Drilling; T. E. Swigart, Shell Pipe Line; Gage Lund, Standard Oil; James W. Liddell, Continental; R. L. Milligan, Pure Oil; James E. Dyer, Sinclair Oil; Davis Bovaird, Bovaird Supply; and Otto Hammer, Security Engineering; Paul Endacott, Phillips; W. K. Whiteford, Gulf; M. J. Rathbone, Standard (New Gulf; M. J. Rathbone, Standard (N.J.).

The board accepted the resignations tendered by E. De Golyer and Wirt Franklin whose term of office normally would not expire until November 1953. To fill these vacancies the board elected, respectively, F. Windfohr, of Nash and Windfohr, and Roland V. Rodman, of Anderson-Prichard Oil. All other members of the board were re-elected.

Net Incomes Down for 9 Months of 1952

In an overall survey of oil industry earnings reported for the first nine months of the year it was revealed that net incomes were lower than the comparable period for 1951. In contrast gross incomes were up, revealing that higher operating expenses, taxation, etc., brought lower net returns.

Sunray Oil, however, reported both gross and net incomes up for the first nine months of the year. Net income was $18,572,000 compared with $17,999,000 last year. General American has just released its annual income as of June 30, showing both net and gross incomes higher. Net income for the year totaled $4,656,704 against $4,477,269 last year.

Atlantic's net income for the first nine months totaled $31,149,211 compared with $31,987,761 last year.

Bishop reported net income of $82,373 compared with $216,758 last year, with lower gross income also.

Continental's first nine months have shown lower net, $27,995,000 compared with $31,304,000 last year, despite higher sales.

Derby Oil reported a net income of $704,020, down from the $998,281 reported last year.

Houston Oil had higher gross income, but net income was down to $4,389,334 compared with $5,275,407.

Lion's net income was down to $7,528,068 from $8,305,246 despite higher sales.

Maracaibo's net income was $243,129 compared with $461,632 last year, with increased gross income.

Mid-Continent reported higher gross income, but a net income of $11,739,036 down from $13,281,652.

Ohio Oil's net income for the first nine months was just slightly lower than last year, $30,425,562 from $30,950,402.

Phillips gross income was up, and net income of $56,292,149 was above the same period last year.

Shell Oil had a net income of $62,656,651 under the $68,770,651 of last year.

Sinclair Oil reported higher gross income the first nine months this year and higher net income, $64,085,436 compared with last year's $58,431,456.

Skelly's net income for the first nine months totaled $19,855,983 compared with $22,036,961. Gross income was up.

Standard of California also reported higher gross income but a net income slightly under the same period last year, $130,364,015 to $130,460,780.

Tidewater reported lower net income for the first nine months, $24,828,000 down from $26,771,000 last year.

Oil Imports in U. S. Pass 1,000,000 Bbl a Day Mark

Imports of foreign crude into the United States passed one-million barrel a day in the week ending October 18, the API reported.

Total amount was 1,095,400 bbl a day, of which 761,600 bbl a day was crude oil and 295,000 residual fuel oil. Imports stayed above that high during the week ended October 25, when they reached 1,011,300 bbl per day, but dropped below that the next week.

Week ended	Crude oil	Residual oil	Others	Total
October 18.....	761,600	295,900	37,900	1,095,400
October 25.....	695,900	315,400	.....	1,011,300
November 1.....	578,000	325,100	25,900	929,000

Exports for the weeks ending September 19, 26, October 3, and 10 are set out below in thousands of barrels a day by the Petroleum Administration for Defense:

	Avgas	Motor gasoline	Kerosine	Distillate	Residual	Total
September 19	25.9	16.5**	26.1	112.1	46.2	226.8
September 26	33.6	5.9	29.9	60.7	18.0	148.1*
October 3....	22.9	33.5	29.0	111.3	14.6	211.3
October 10...	41.0	17.3	21.0	59.9	42.8	192.0
Change in four weeks ending October 1 compared with four weeks ending September 12.						
	−1.9	−8.5	+19.1	+ 1.2	−16.4	−6.5

During a special ceremony at the Pentagon, Secretary of the Navy Dan A. Kimball (right) presented B. Brewster Jennings (center), president of the Socony-Vacuum Oil Company, Inc., of New York, the Secretary of the Navy's Distinguished Public Service Award, the highest award the Navy may confer on a civilian for his exceptional contributions in logistics during World War II. Secretary of Defense Robert A. Lovett (left), other defense department officials, and friends attended the ceremony.

Ted Sutter, J. A. Crawford, E. S. Dulin, D. S. Faulkner, honor guest, and Floyd Merritt. E. S. Dulin is presenting PESA honor scroll to D. S. Faulkner.

PESA Honors Faulkner

Los Angeles area members of the Petroleum Equipment Suppliers Association met recently in the Gold Room of the Ambassador Hotel to do honor to David S. Faulkner, retired president of National Supply Company, and one of the best known and best loved men in the petroleum equipment industry. The honor guest was given a scroll, testifying to his good works and the high regard in which he is held by the people of his profession.

The presentation was made by E. S. Dulin, president of Byron-Jackson Company. He spoke of the early Faulkner influence on other young men of his time who were struggling for recognition in a new enterprise. Jack Crawford, president of Youngstown Steel Products Company. of California, told of the part played by the guest of the evening in the organization of PESA, and of his subsequent lively interest and support. Other speakers who extolled Dave Faulkner were Floyd Merritt, vice president of Byron-Jackson; Ted Sutter, vice president of Baker Oil Tools; John Spalding, the Faulkner successor at National Supply Company, and Tom Hickey, president of Hickey Pipe and Supply.

Oil Demand Up 2.7 Per Cent From First Nine Months '51

Total demand for crude oil and refined products during the first nine months of this year were estimated at 7,490,000 bbl of oil daily, the American Petroleum Institute has reported. This is about 2.7 per cent above the comparable 1951 period. API reported that domestic demand from January 1 through September 30 averaged 7,050,000 bbl daily, compared with 6,875,000 a year earlier. Exports totaled 440,000 bbl a day, up from 417,000 in the 1951 period.

Texas Cuts Oil Output

Texas cut its oil allowables this month after two months' of the highest permissible production in the state's history. New allowable is 3,305,770 bbl per day down 66,976 from the November average. Proration is based on 23 days generally for fields and 19 for East Texas, where a big increase in reservoir energy in October was shown. Sun Oil and Sinclair favored the 19-23 pattern, but all others wanted greater reductions.

Foreign Oil Reports Cut to Quarterly Basis

Oil operators constructing foreign petroleum projects approved by the Petroleum Administration for Defense will no longer be required to file monthly progress reports showing the status of construction, Deputy Petroleum Administrator J. Ed Warren reported. From now on, Warren said, such reports will be required only on a quarterly basis.

The quarterly reports must be filed with PAD on Form IT/PAD-26A, Supplement, not later than the 15th of the month following the close of the calendar quarter. The reports are required each quarter until the project reported on has been completed.

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OPS Grants Same Producers Price Rise of Natural Gas

The Office of Price Stabilization has issued an order permitting automatic increases in price of natural gas called for at set intervals under long-term contracts signed before prices were frozen January 26, 1951. Prices may be raised even though they may rise above the ceiling in that particular area.

A competing producer, however, who does not have a contract is forbidden to raise his prices simply because his competitor can do so by the new order. Until this latest ruling was made, producers could raise prices under certain circumstances if a competitor did so.

At Wichita Falls D & D banquet are Mrs. Lamont Tofte, Texas Seismograph, national treasurer and local first vice president; Mrs. M. E. McCullough; M. E. McCullough, president, North Texas Oil and Gas Association, Wichita Falls, Texas; Mrs. Evelyn Halverson, Humble, immediate past president, and Miss Lela Porter, Bridwell Oil, president, Desk & Derrick Club of Wichita Falls.

D & D News

Austin, Texas, oil women set up that city's first chapter of Desk and Derrick Club recently. Organizing committee included, Lucy Johnson, Oil and Gas Division, Railroad Commission of Texas, chairman; Lolly Roepks, Myrl Beaty, June Grundy, Kay Telford, Louise Kirk, Agnes Miller, Ellen Brubaker, Peggy Studer, and Grace Kincaid. Attending the organizational dinner held in Austin recently were Doris Whiteside, Dallas, director for Region VI, and Irene Stimson Cox, San Antonio, first vice president of the National Association.

From Philadelphia comes word of the William Penn Desk and Derrick Club. The Philadelphia chapter was organized in June with 32 charter members. First program meeting was held recently with a "get-acquainted program" to introduce more than 100 new members.

U. S. Oil Demand to Rise In 1953, IPAA Believes

United States demand for oil in 1953 will average 7,674,000 bbl daily or 4.9 per cent more than in 1952, the Supply and Demand Committee of the Independent Petroleum Association of America estimated recently.

The Committee said total demand for both domestic use and exports would average 7,967,000 bbl a day next year—an increase of 3.3 per cent.

Inventories of crude oil and refined products, reported standing at 681,000,000 bbl last September 30, will drop to 626,000,000 bbl by next March 31 and bounce back to 698,000,000 bbl on September 30, 1953, the committee reported.

The committee also forecast total domestic and export demand for the six months ending March 31, 1953. It said demand for this period would total 8,339,000 bbl a day, or 4.2 per cent more than the same period a year ago.

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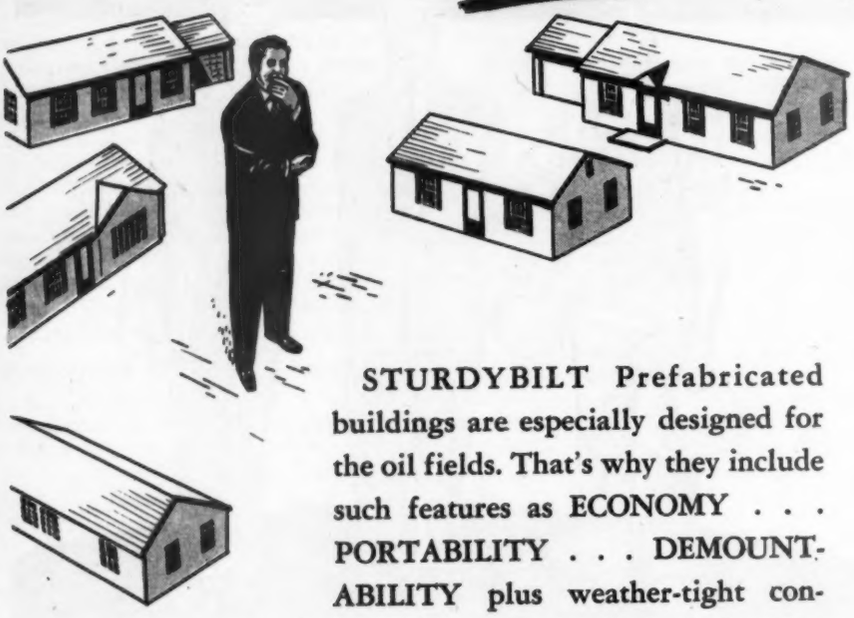

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API Gives Special Award To Oil Men at Annual Meet

Forty-eight oil men were given special honors at the 32nd annual meeting of the American Petroleum Institute recently. They were presented with the API's "Certificate of Appreciation" in recognition of meritorious service and contributions to the work of the Institute and the industry.

Recipients were:

Research. Kenneth C. Heald, Gulf; Charles V. Millikan, Amerada; A. E. Miller, Sinclair; W. J. Sweeney, Standard Oil Development.

Transportation. Harry S. Elkins, NPA; H. A. Gilbert, Oil Transfer; F. W. Littell, Shell Pipe Line; C. R. Musgrave, Phillips; M. E. Nuttila, Cities Service; J. H. Peper, Buckeye Pipe Line; J. J. Powelson, Esso Standard.

Oil Industry Information Committee. Walter E. Black, Esso Standard; Ralph F. Carey, Shell; Madison Farnsworth, Gulf; Thad E. Horton, Texaco; George D. McDaniel, Socony-Vacuum; George F. McMillan, Gulf; Harry E. Milton, Milton Oil; R. T. Seidel, Shell; E. L. Stauffacher, Cities Service; Harry A. Trower.

American Petroleum Industries Committee. James J. Cosgrove, Continental (Ohio); George F. Prussing, consulting engineer; H. J. Wilson, Tidewater; B. A. Moeller, General Petroleum.

Petroleum Reserves. F. H. Lahee, Sun; J. Melville Sands, retired, Phillips.

Marketing. Harry J. Kennedy, Continental; E. J. McClanahan, Standard Cal; A. A. Stambaugh, Standard (Ohio).

Division of Production. H. H. Anderson, resigned, Shell Pipe Line; C. W. Froome, resigned, Union Cal.; H. M. Henderson, resigned, Standard Cal.; M. J. Kirwan, resigned, Cities Service; Ray F. Shumaker, retired, Sinclair Pipe Line; P. R. Applegate, Buckeye Pipe Line; F. E. Bernsen, Lucey Products; Charles Fitzgerald, Sinclair Refining; Gwynne Raymond, Union Tank and Supply; M. E. Schwarz, Seaboard Oil; J. C. Askam, Ohio Oil; S. B. Terry, Munitions Board Cataloging Agency; A. J. Morgan, John A. Roebling's Sons; L. A. Ogden, Pure Oil; J. J. Schmidt, East Ohio Gas; F. J. Spang, Spang and Company.

U. S. Oil Stocks Rise

Crude oil stocks in the United States rose 1,060,000 bbl for the third consecutive weekly increase the week ending November 1, according to the Bureau of Mines, putting stock total at 268,535,000 bbl. This is 1.3 per cent increase from a year earlier. This compares with 267,475.000 bbl for the preceding week.

Ralph Dietler, Stanolind Oil Purchasing Company, reported to the Texas Railroad Commission that United States' stocks of 268,535,000 bbl are 12,000,000 greater than when the year began. Storage of four principal products totals 327,692.000 up 52,250,000 bbl, he added.

In other states main increases were in Wyoming, 369,000 bbl, and in Louisiana, 202.000 bbl. Decreases were seen in Oklahoma, foreign crude stored in the U. S., and in Appalachian crude.

Property Division Asked

Pancoastal Oil Corporation has proposed to its stockholders that it separate its Venezuelan and Florida holdings and operate the two as two companies.

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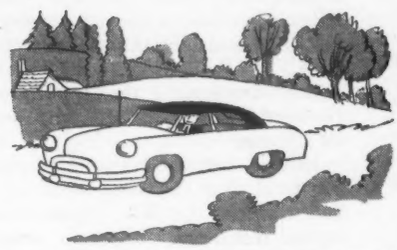
1. 

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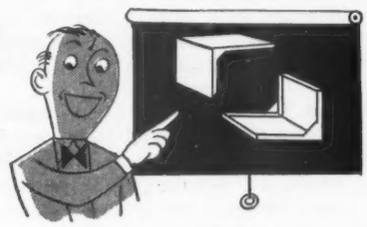
2. 

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Name_____ Title_____

Organization_____

Address_____ City_____ State_____

RCA **RADIO CORPORATION of AMERICA**
MOBILE COMMUNICATIONS CAMDEN, N. J.

PERSONALS

H. A. Jarvis has been named a director of the Creole Petroleum Corporation and **L. E. Lowry** as comptroller to replace **I. R. Cunningham,** director and controller who resigned recently.

Cunningham has accepted a position with the producing coordination department of the Standard Oil Company (New Jersey).

Jarvis has been associated with the Creole Petroleum Corporation and other affiliated companies of Standard Oil since 1930 when he was employed in Esso's Bayway refinery as a student engineer. He went to Venezuela in 1947 as assistant manager of the refinery department of the Creole Petroleum Corporation in Caracas, and the following year was appointed manager of the company's refinery in Amuay. He was appointed a member of the management committee of Creole in Venezuela in 1940. Jarvis is presently manager of the western division of the Creole Petroleum Corporation in Maracaibo, Venezuela.

Leo Lowry joined Carter Oil, an affiliate of the Standard Jersey, in June 1937. He went to Venezuela as an accountant with the Standard Oil Company of Venezuela in March, 1938, and has remained in that country since that time. He is at present an assistant comptroller and manager of the accounting department of the Creole Petroleum Corporation.

George G. Green, independent oil man, has been named president for 1953 of the Mississippi-Alabama Division, Mid-Continent Oil and Gas Association, during the Association's eighth annual meeting in Biloxi, Mississippi, recently. Former vice president of the Association, Green replaces **E. B. McGehee** of Jackson.

Other officers include: **E. L. Brunini,** Vicksburg, vice president, and **E. D. Kenna,** Jackson, re-elected executive vice president and director for the coming year.

New vice presidents include: **James L. Duffy, A. B. Friend, Dennis Granberry, Robert Lee Jones, Buford Yerger, Barnett Serio, J. Finley McRae.**

General board of directors is made up of: **B. W. Haywood,** Gulf Refining; **Lucius M. Lamar,** California Company; **J. P. Evans, Jr., Charles McFadden, Russ M. Johnson, W. M. Vaughey, George Wallace,** and McGehee, all of Jackson.

H. B. (Hi) Gernert has been named president of the Rocky Mountain Oil and Gas Association at the annual meeting in Denver, Colorado, recently. Gernert is general manager of the Trigood Oil Company at Casper, Wyoming. He spent several years in Montana as production superintendent for The Texas Company.

Other officers include: **A. F. Barrett,** General Petroleum, vice president; **R. S. Shannon, Jr.,** Pioneer Oil Company, vice president; **W. M. Saxon,** Pure Oil, vice president for Montana, and South Dakota, and **Walter G. Davis,** Casper independent, re-elected treasurer.

Jacques Ellison, Jr., has been appointed senior district representative of the Oil Industry Information Committee in New England it was announced by Edwin W. Esmay, acting director, department of Information, American Petroleum Institute. Ellison will succeed **John B. Goodman,** who has resigned to become assistant director of public relations, The American Oil Company. Ellison has been a district representative in the Kansas-Oklahoma district of the OIIC. To fill his place in the Tulsa office, Esmay announced the appointment of **Richard H. Robinson** of Oklahoma City, Oklahoma.

Ellison attended the University of Missouri and the University of Tulsa and received his BA degree from the latter. Robinson, following newspaper and oil field work, became associated with the Erwin, Wasey Advertising Agency as a copy writer in 1947 and later was promoted to an account executive of that firm.

A. D. Cadman has been named manager of the Industrial Relations Department of The British American Oil Company, Ltd. For the past seven years Cadman has held key positions in the company's marketing organization in Ontario and Quebec.

Edward J. Gesick, formerly with Mills Industries of Chicago, has been named treasurer of Southwest Research Institute and its affiliates, The Southwest Foundation for Research and Education and the Institute of Inventive Research. As secretary-treasurer of Mills Industries, Gesick assisted in a reorganization of the company and its subsidiaries.

T. L. Lenzen

T. L. Lenzen has been elected vice president of Standard Oil Company of California. Lenzen has been manager of Standard's Eastern Hemisphere Operations and has been closely affiliated with Middle East oil developments since 1938. He has spent considerable of his time abroad as coordinator in the administration of Standard's interests in the affiliated producing, refining, transportation, and marketing companies doing business in the Eastern Hemisphere.

He is a director of Bahrein Petroleum Company Ltd., California Texas Oil Company, Ltd., and Overseas Tankship Corporation. The new vice president joined Standard in 1928 after graduation and a year of graduate work in electrical engineering at Stanford University.

Quinton Peters has been named manager of publications in the advertising department of Deep Rock Oil Corporation. Former feature writer of *The Tulsa World,* Peters as Oklahoma University graduate, replaces Jim Holmes.

Jack A. Vickers, Jr.

John S. Wertz

James B. Smith

Jack A. Vickers, Jr., 27-year-old son of the former Jack A. Vickers, Sr., founder of the Vickers Petroleum Company, became president of that company recently. At the same time **John S. Wertz,** president for the past four years, assumed the office of chairman of the board of directors. In another major executive shift, **James Beattie Smith,** who has been vice president and a member of the board of directors since 1941, will become executive vice president.

Jack Vickers, the new president of Vickers Petroleum, has been with the Vickers Petroleum enterprise, an independent, family-owned operation, since 1946, when he began in the scouting end of the business.

Wertz, the new chairman of the board of directors has been with Vickers for the last 31 years, during which time he served as secretary and treasurer for 26 years.

Smith, who assumes the executive vice presidency, came to Vickers Petroleum Company from Skelly Oil Company in 1937, after 11 years with that concern. Beginning as sales manager for Vickers in 1937, Smith was made a vice president and member of the board of directors in 1941.

Simultaneous with the installation of the officers in new posts, the company announces that the new $3,500,000 catalytic cracking unit at their Potwin, Kansas refinery will go into production the end of January, 1953, on the 35th anniversary of the founding of the company.

Personals

Millard E. Stone

Millard E. Stone has been named director of industrial relations for Sinclair Oil Corporation. For the last 10 years, Stone has been director of industrial relations, Bendix Products Division, Bendix Aviation Corporation, South Bend, Indiana. Presently chairman of the industry members of the Wage Stabilization Board in Washington, Stone was an industry member of the former Wage Stabilization Board and also served on the War Labor Board during World War II.

Philip J. Clough has been named assistant director of the metallurgical department of the National Research Corporation. Clough has been employed by National Research since 1946 where he has been a project manager until his recent advancement. He is a graduate of Bowdoin College and Middlebury College.

Minor S. Jameson, Independent Petroleum Association of America, has been named by the Petroleum Administration for Defense to serve as one of six consultants to continue investigation of the crude oil productive capacity of the United States. Other consultants are: **Stewart Buckley,** Humble Oil; **Everett Trostel,** DeGolyer and MacNaughton; **Earl Neal,** Standard Oil (New Jersey); **Edmund C. Babson,** Union Oil, and **Paul Schultz,** Stanolind Oil and Gas.

Dr. Edgar V. Murphree, president of Standard Oil Development Company (New Jersey), has been named recipient of the Industrial Research Institute Medal. The award has been given annually since 1945 for "outstanding accomplishment in leadership in or management of industrial research which contributes broadly to the development of industry or the public welfare." He will be formally presented the medal at the annual meeting of the institute in White Sulphur Springs, West Virginia, in April, 1953. Dr. Murphree was named Standard Oil Development president in 1947.

Charles F. Parker, supervisor of economics for Union Oil Company of California, has been elected assistant comptroller, it was announced by Reese H. Taylor, president. Parker will be in charge of economics. Parker holds both bachelor's and master's degrees in chemical engineering from University of Southern California. He has been with Union Oil for 20 years.

F. Roe Weise, assistant director of industrial relations, has been appointed associate director of industrial relations of Standard Oil Company, a new position. **E. W. Ahern** and **J. P. Nielsen** have been appointed assistant directors of industrial relations of the company.

Weise joined Standard in 1936. In 1941 he was promoted to the general office in Chicago as assistant manager of labor relations. He was appointed assistant director of industrial relations in 1943. Weise is a graduate of the University of Iowa and the George Washington University School of Law.

Ahern, supervisor of the training section in the industrial relations department, joined Standard in 1933. Transferred to the industrial relations department early in 1948, he became supervisor of the training section later that year. Ahern is an alumnus of the University of Chicago.

Nielsen joined the company in 1917 as a timekeeper at the Whiting refinery. After a series of advancements, he became office manager at the Sugar Creek, Missouri, refinery in 1936. He was advanced to superintendent of the industrial relations division at the Whiting refinery in 1950, his former position.

Arthur F. Turman has been appointed chief petroleum engineer for the Standard Oil Company of California's producing department in the San Francisco home office. He succeeds **W. A. Eardley,** who was recently appointed manager of the department's Northern district at Taft, California.

J. T. Crooker, previously supervising petroleum engineer for the producing department at Taft, succeeds Turman as assistant chief petroleum engineer in San Francisco.

A native of Terre Haute, Indiana, Turman is a graduate of the University of Chicago and joined the company in 1920 as a geologist. Crooker, born in Tucson, Arizona, joined Standard of California in 1938, beginning as an oil field roustabout.

Charles S. Mitchell was elected vice president of Cities Service Oil Company. Mitchell is a member of the board of directors of Cities Service and president of Cities Service Pipe Line. He has been connected with Cities Service since 1930 when he joined the company as a junior engineer.

John A. Fuller has been named to the board of directors by British American Oil Company, Ltd. President of the Shawinigan Water and Power Company, Fuller is also president of Quebec Power Company and St. Maurice Power Corporation. Fuller is a vice president and director of Shawinigan Chemicals Ltd., and Canadian Resins and Chemicals.

F. W. Brigance, newly elected president of the American Association of Oil Well Drilling Contractors, has been appointed to membership on the National Petroleum Council, it was announced by Deputy Petroleum Administrator J. Ed Warren. Brigance succeeds **A. W. Thompson** of Houston, Texas, retiring president of the association.

Deaths

Charles S. Hill, Colorado and Wyoming oil man and past president of the Rocky Mountain Oil and Gas Association, died in Chicago, Illinois, November 10, while attending the annual meeting of the American Petroleum Institute. An independent operator, Hill was elected president of the association in 1950 and re-elected for a second term in 1951. He was credited with discovery of several fields.

J. D. Baker, purchasing agent for the central division, Stanolind Oil and Gas Company, Oklahoma City, died October 27 after a long illness. He joined Stanolind in 1935, and was a member of the Purchasing Agents Association.

William M. Welch, retired petroleum engineer, died October 29 at his home in Tulsa, Oklahoma. Before his retirement he had been vice president of the Tidal Refining Company. He was organizer and first president of the Natural Gasoline Association of America and a founder of the Natural Gas Association of America, now the natural gas department of the American Gas Association. He was a past president of the Natural Gasoline Manufacturers. He graduated from Stevens Institute of Technology.

R. B. "Bob" Block died November 3 at his home in Whittier, California, following a lingering heart ailment. Block was especially well known to members of Nomads and others engaged in the export end of the petroleum equipment business. He had been drilling superintendent for International Petroleum Company in Peru for many years. For a time after his retirement from IPC, he was associated with Paul Cavins at Long Beach, and later still was employed for a time as drilling superintendent in Alaska by Arctic Contractors. He was a member of Nomads and the Petroleum Production Pioneers.

A. E. Lacomble, retired chairman of the board and former president of the Shell Development Company, died at Stanford Hospital, November 5 following an extended illness. Lacomble received his Doctorate in Science from the University of Leyden in The Netherlands and joined the Shell Group in 1920.

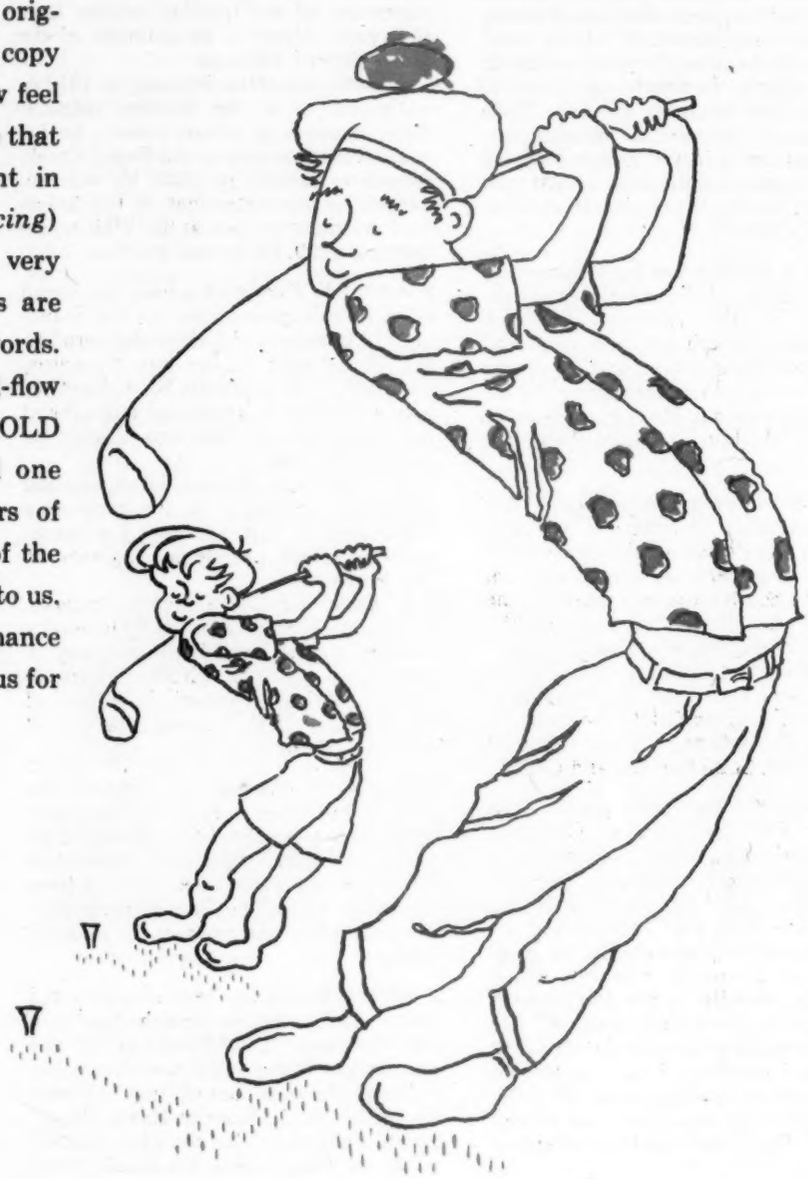
After five years with Shell in the Netherlands East Indies, he was named assistant superintendent of the Martinez refinery. He later was transferred to the Wilmington refinery and in 1930 joined Shell Development in Emeryville.

Lacomble was named vice president for manufacturing with Shell Oil Company in 1932 and eight years later returned to Shell Development as vice president. On January 1 of 1943 he was promoted to the presidency of Shell Development and six years later became chairman of the board. He retired December 31, 1951.

Russell S. Roeller, general sales manager of the Pennsylvania Salt Manufacturing Company, died November 12. Roeller joined Pennsalt in 1922. He was made Philadelphia district sales manager in 1933, field sales manager in 1942, and assistant general manager in 1950.

We're Flattered to be Imitated

A fellow's ego gets a wonderful boost when he does something so well, so new and original, that people want to copy him. All of us at Winslow feel highly flattered to realize that after all our years spent in preaching (*and practicing*) full-flow filtration, some very well-known competitors are beginning to echo our words. But when you want full-flow filters that catch and HOLD more dirt, there's still one name, after twenty years of leadership, at the head of the list. It is Winslow. Write to us. Ask about our performance and our Warranty, famous for its Extra Protection!



WINSLOW FILTERS

Winslow Engineering Company 4069 Hollis Street, Oakland 8, California

TON MILES

2⅞-in. drill pipe — 10.4 lb. per foot

60,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	2	5	7	10	12	14	17	19	21
1000	24	26	29	31	34	36	39	41	44	47
2000	49	52	54	57	60	62	65	68	71	74
3000	76	79	82	85	88	91	94	96	99	103
4000	105	108	111	114	117	120	124	127	130	133
5000	136	139	142	146	149	152	155	159	162	165
6000	168	172	175	179	182	185	189	192	196	199
7000	203	206	210	213	217	221	224	228	231	235
8000	239	243	246	250	254	257	261	265	269	273
9000	277	280	284	288	292	296	300	304	308	312
10000	316	320	324	328	332	336	340	345	349	353
11000	357	361	366	370	374	379	383	387	391	396
12000	400	405	409	413	418	422	427	431	436	440
13000	445	450	454	459	463	468	472	477	482	487
14000	491	496	501	506	511	515	520	525	530	535
15000	540	545	550	555	560	565	570	575	580	585
16000	590	595	600	605	610	616	621	626	631	636
17000	642	647	652	658	663	668	674	679	684	690
18000	695	701	706	712	717	723	728	734	739	745
19000	751	756	762	767	773	779	785	790	796	802

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 2⅞-in., 10.4 lb drill pipe and 60,000 lb excess weight = 422.

TON MILES

3½-in. drill pipe — 13.3 lb. per foot

15,000 lb EXCESS WEIGHT

0	0	1	1	2	2	3	4	5	5	6
1000	7	8	9	9	10	11	12	13	14	15
2000	16	17	18	19	20	22	23	24	25	26
3000	28	29	30	31	33	34	35	37	38	40
4000	41	43	44	46	47	49	51	52	54	55
5000	57	59	61	62	64	66	68	70	72	73
6000	75	77	79	81	83	85	87	89	92	94
7000	96	98	100	102	105	107	109	111	114	116
8000	118	121	123	126	128	131	133	136	138	141
9000	143	146	149	151	154	157	159	162	165	168
10000	171	173	176	179	182	185	188	191	194	197
11000	200	203	206	209	213	216	219	222	225	229
12000	232	235	238	242	245	249	252	255	259	262
13000	266	269	273	276	280	284	287	291	295	298
14000	302	306	310	313	317	321	325	329	333	337
15000	340	344	348	352	357	361	365	369	373	377
16000	381	385	390	394	398	402	407	411	415	420
17000	424	429	433	438	442	447	451	456	460	465
18000	469	473	478	483	487	491	496	501	506	510
19000	516	521	526	531	536	541	546	551	556	561

20,000 lb EXCESS WEIGHT

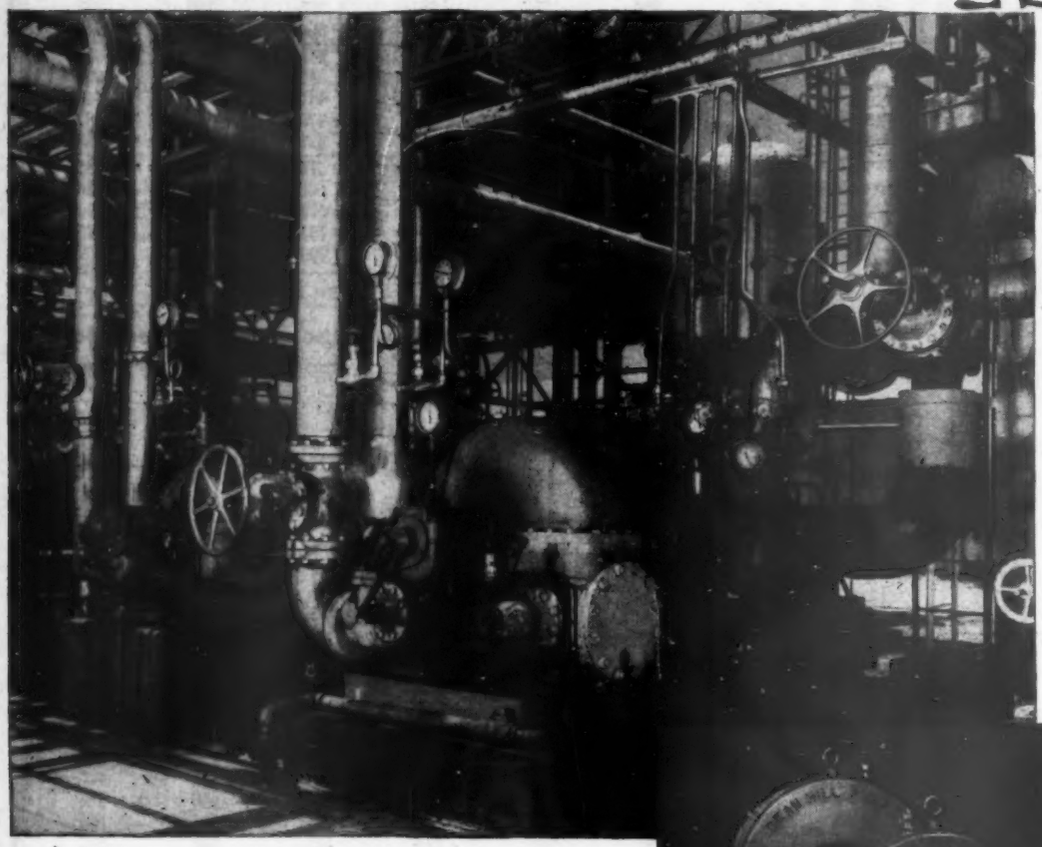
0	0	1	1	2	3	4	5	6	7	8
1000	9	10	11	12	13	14	15	16	17	19
2000	20	21	22	24	25	26	28	29	30	32
3000	33	35	36	38	39	41	42	44	45	47
4000	49	50	52	54	56	57	59	61	63	65
5000	67	69	70	72	74	76	78	80	83	85
6000	87	89	91	93	95	98	100	102	104	107
7000	109	111	114	116	119	121	124	126	129	131
8000	134	136	139	141	144	147	149	152	155	158
9000	160	163	166	169	172	175	178	181	184	187
10000	190	193	196	199	202	205	208	211	214	218
11000	221	224	227	231	234	237	241	244	248	251
12000	255	258	262	265	269	272	276	279	283	287
13000	290	294	298	302	305	309	313	317	321	325
14000	329	332	336	340	344	348	352	357	361	365
15000	369	373	377	381	386	390	394	398	403	407
16000	412	416	420	425	429	434	438	443	447	452
17000	456	461	466	470	475	480	484	489	494	499
18000	504	508	513	517	522	527	532	537	542	547
19000	552	557	562	567	572	578	583	588	593	599

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 3½-in., 13.3 lb drill pipe and 15,000 lb excess weight = 249.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

How to stretch a "Power Penny"

You'll never know how much power a penny will buy until you get Dean Hill Steam Turbines on the job. Their super rugged construction, their service-engineered design, their low maintenance, their remarkable power-producing ability all add up to *more power per penny.*



POWER AT WORK

Here are Dean Hill Type DH Steam Turbines at work driving centrifugal pumps at Bay Petroleum Corporation's Chalmette, La. refining operation.

DEAN HILL TURBINES are specifically designed for operation at medium steam pressures. Since they are the single stage, double impact type, low steam consumption is a tremendous economy feature. Steam rates are excellent under these conditions. Get full details and specifications. Write today.

DEAN HILL PUMP COMPANY

Pump and Turbine Engineers Since 1895

INDIANAPOLIS 7, INDIANA

Chicago • New York • San Francisco • Boston • Denver • Albuquerque • El Paso • Salt Lake City • New Orleans • Philadelphia • Tulsa • Los Angeles • Pittsburgh • Houston • Dallas St. Paul • Toledo • Cleveland • Grand Rapids • Birmingham, Ala. • Louisville • Memphis • Nashville • Richmond • Bogota, Col. • Mexico City • Montreal • Reading, Pa. • The Hague, Neth.

TON MILES

3½-in. drill pipe — 13.3 lb. per foot

25,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	1	2	3	4	5	6	7	8	10
1000	11	12	13	14	16	17	18	20	21	22
2000	24	25	27	28	29	31	33	34	36	37
3000	39	41	42	44	46	47	49	51	53	55
4000	56	58	60	62	64	66	68	70	72	74
5000	76	78	80	82	85	87	89	91	93	96
6000	98	100	103	105	107	110	112	115	117	120
7000	122	125	127	130	133	135	138	141	143	146
8000	149	152	154	157	160	163	166	169	172	175
9000	178	181	184	187	190	193	196	199	202	205
10000	209	212	215	218	222	225	228	232	235	238
11000	242	245	249	252	256	259	263	266	270	274
12000	277	281	285	288	292	296	300	303	307	311
13000	315	319	323	327	331	335	339	343	347	351
14000	355	359	363	367	372	376	380	384	389	393
15000	397	402	406	410	415	419	424	428	433	437
16000	442	446	451	456	460	465	470	474	479	484
17000	489	493	498	503	508	513	518	523	528	533
18000	538	542	547	552	557	562	567	573	578	583
19000	588	593	599	604	609	614	620	625	631	636

30,000 lb EXCESS WEIGHT

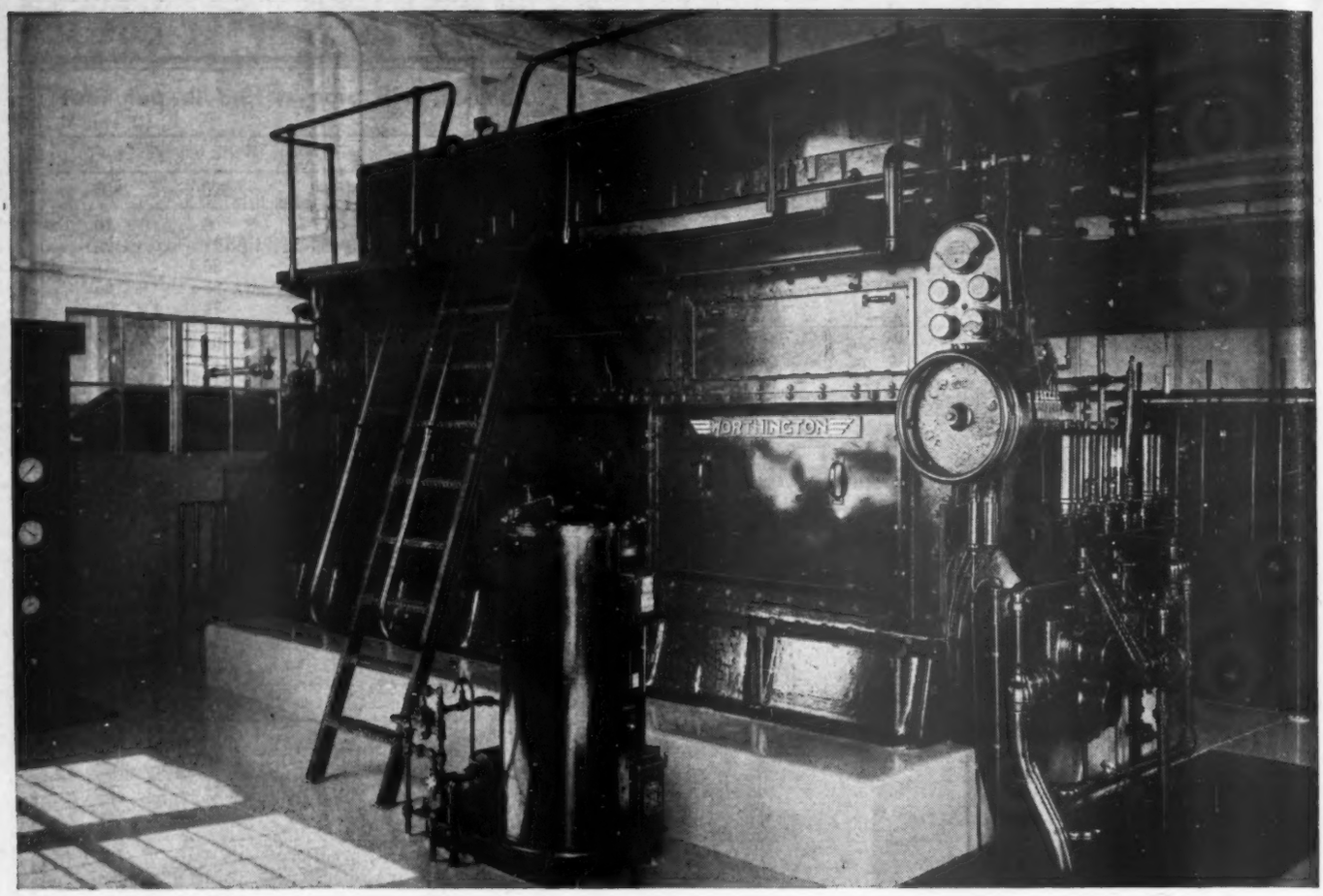
0	0	1	2	3	4	6	7	9	10	11
1000	13	14	15	17	18	20	21	23	24	26
2000	27	29	31	32	34	36	37	39	41	43
3000	45	46	48	50	52	54	56	58	60	62
4000	64	66	68	70	72	74	77	79	81	83
5000	86	88	90	92	95	97	100	102	104	107
6000	109	112	114	117	120	122	125	127	130	133
7000	136	138	141	144	147	149	152	155	158	161
8000	164	167	170	173	176	179	182	185	188	191
9000	195	198	201	204	207	211	214	217	221	224
10000	227	231	234	238	241	245	248	252	255	259
11000	262	266	270	274	277	281	285	289	292	296
12000	300	304	308	312	316	320	324	328	332	336
13000	340	344	348	352	356	360	365	369	373	377
14000	382	386	390	395	399	403	408	412	417	421
15000	426	430	435	439	444	449	453	458	463	467
16000	472	477	482	486	491	496	501	506	511	516
17000	521	526	531	536	541	546	551	556	561	567
18000	572	576	581	586	591	597	602	608	613	618
19000	623	629	635	640	646	651	657	662	668	673

35,000 lb EXCESS WEIGHT

0	0	1	2	4	5	7	8	10	11	13
1000	14	16	18	19	21	23	24	26	28	29
2000	31	33	35	37	39	40	42	44	46	48
3000	50	52	54	56	58	61	63	65	67	69
4000	72	74	76	78	81	83	85	88	90	93
5000	95	98	100	103	105	108	110	113	115	118
6000	121	123	126	129	132	135	137	140	143	146
7000	149	152	155	158	161	164	167	170	173	176
8000	179	182	185	189	192	195	198	202	205	208
9000	212	215	218	222	225	229	232	236	239	243
10000	246	250	254	257	261	265	268	272	276	280
11000	283	287	291	295	299	303	307	311	315	319
12000	323	327	331	335	339	343	347	352	356	360
13000	364	369	373	377	382	386	390	395	399	404
14000	408	413	417	422	426	431	435	440	445	449
15000	454	459	464	468	473	478	483	488	493	497
16000	502	507	512	517	522	527	532	538	543	548
17000	553	558	563	569	574	579	584	590	595	600
18000	606	611	616	621	625	632	638	643	649	655
19000	660	666	671	677	683	688	694	700	706	712

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 3½-in., 13.3 lb drill pipe and 25,000 lb excess weight — 296.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation



No Standby Needed

Worthington Reliability Saves Thousands of Dollars in Investment Cost

Here's one of twelve Worthington Diesel engines used exclusively on a large oil pipe line running across Texas.

They power the pumps which maintain a constant flow of crude oil from field to refinery.

In none of the pumping stations is there a standby engine. The pipeline company is confident that its Worthington Diesels will *stay on the job.*

Portable pumping units are connected into the line during routine maintenance checks.

Engine fuel is raw crude bled from the line. This is a severe application. But Worthington — one of the first to utilize crude for Diesels — knows how to lick the problem.

For any engine application, call on Worthington — an engine for any fuel: oil (crude or regular), gas or "dual fuel". Worthington's complete line of engines assures you of the most economical operation no matter what fuel you use.

For further information, write Worthington Corporation, Engine Division, Buffalo, New York.

WORTHINGTON

ENGINES

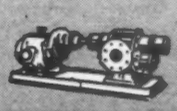
E.1.5

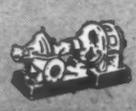
ECONOMICAL CONTINUOUS POWER

Diesel Engines, 150 to 2640 hp
Gas Engines, 190 to 2880 hp
Dual Fuel Engines, 345 to 2640 hp

WORTHINGTON-BUILT AUXILIARIES

Engine Starting Compressors


Oil Transfer Pumps


Cooling Water Circulating Pumps

Evaporative Type Engine Water Coolers

TON MILES

3½-in. drill pipe — 13.3 lb. per foot

40,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	2	3	4	6	8	10	11	13	15
1000	16	18	20	22	24	25	27	29	31	33
2000	35	37	39	41	43	45	47	49	52	54
3000	56	58	60	63	65	67	70	72	74	77
4000	79	82	84	86	89	92	94	97	99	102
5000	104	107	110	113	115	118	121	124	126	129
6000	132	135	138	141	144	147	150	153	156	159
7000	172	165	168	171	175	178	181	184	188	191
8000	194	198	201	204	208	211	215	218	222	225
9000	229	232	236	239	243	247	250	254	258	262
10000	265	269	273	277	281	285	288	292	296	300
11000	304	308	312	316	320	325	329	333	337	341
12000	345	350	354	358	363	367	371	376	380	384
13000	389	393	398	402	407	411	416	421	425	430
14000	435	439	444	449	453	458	463	468	473	478
15000	483	487	492	497	502	507	512	517	523	528
16000	533	538	543	548	553	559	564	569	575	580
17000	585	591	596	601	607	612	618	623	629	634
18000	640	645	651	656	662	667	673	679	685	690
19000	696	702	708	714	720	725	731	737	743	749

45,000 lb EXCESS WEIGHT

0	0	2	4	5	7	9	11	13	14	16
1000	18	20	22	24	26	28	30	32	35	37
2000	39	41	43	45	47	50	52	55	57	59
3000	62	64	66	69	71	74	76	79	81	84
4000	87	89	92	95	97	100	103	106	108	111
5000	114	117	120	123	125	128	131	134	137	140
6000	143	146	150	153	156	159	162	165	169	172
7000	175	179	182	185	189	192	195	199	202	206
8000	209	213	216	220	224	227	231	234	238	242
9000	246	249	253	257	261	264	268	272	276	280
10000	283	288	292	296	300	304	308	312	316	321
11000	325	329	333	337	342	346	350	355	359	363
12000	368	372	377	381	386	390	395	399	404	408
13000	413	418	422	427	432	436	441	446	451	456
14000	461	465	470	475	480	485	490	495	500	505
15000	510	515	520	526	531	536	541	546	552	557
16000	562	568	573	578	584	589	595	600	605	611
17000	617	622	628	634	639	645	650	656	662	667
18000	673	679	685	690	696	702	708	714	720	726
19000	732	738	744	750	756	762	768	774	780	787

50,000 lb EXCESS WEIGHT

0	0	2	4	6	8	10	12	14	16	18
1000	20	22	24	27	29	31	33	36	38	40
2000	43	45	47	50	52	55	57	60	62	65
3000	67	70	73	75	78	80	83	86	89	91
4000	94	97	100	103	106	109	111	114	117	120
5000	123	126	130	133	136	139	142	145	148	152
6000	155	158	161	165	168	171	175	178	182	185
7000	189	192	196	199	203	206	210	214	217	221
8000	225	228	232	236	240	243	247	251	255	259
9000	263	267	271	275	279	283	287	291	295	299
10000	303	307	312	316	320	324	329	333	337	342
11000	346	350	355	359	364	368	373	377	382	386
12000	391	396	400	405	410	414	419	424	429	433
13000	438	443	448	453	458	463	468	473	478	483
14000	488	493	498	503	508	513	518	524	529	534
15000	539	545	550	555	561	566	571	577	582	588
16000	593	599	604	610	616	621	627	632	638	644
17000	650	655	661	667	673	679	684	690	696	702
18000	708	713	719	725	731	737	743	749	756	762
19000	768	774	780	786	793	799	805	812	818	824

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 3½-in., 13.3 lb drill pipe and 45,000 lb excess weight = 390.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

Special Treatment to Make a Tube Stand Up!

M. W. KELLOGG

Be it for high pressure or high vacuum . . . 1800F. or –260F. . . . rosive or erosive service, exclusive manufacturing techniques lengthen operating life of Kellogg heat exchange equipment.

Pressure Vessels
Vacuum Vessels
Fractionating Columns
Drums and Shells
Heat Exchangers
Process Piping
Hi-pressure—Hi-temp Power Piping
Bends and Headers
Forged and Welded Fittings
Radial Brick Chimneys
Concrete Chimneys

Continuing Basic Study of heat exchange by Kellogg development groups over 20 years has produced unduplicated design data.

Shop Layout Craftsmen have had experience on all types of heat exchangers, from marine condensers to jet engine combustion-chambers.

Rigid Quality Control is maintained by inspectors reporting directly to *Shop Management* rather than to *Production* executives.

Extensive Shop Facilities, from plate forming to stud threading, permit *complete* fabrication of any type heat exchanger.

Special Shop Techniques—the component parts of each exchanger are fabricated as a production unit, building in the advantages of "tailor-made" fit.

FOR OPERATORS IN WESTERN CANADA!

The Canadian Kellogg Company Ltd. has established complete shop facilities for the fabrication of all types of piping at EDMONTON, Alberta. Inquire directly or through any Kellogg or Canadian Kellogg office.

Fabricated Products Division, The M. W. Kellogg Company

New York, Jersey City, Los Angeles, Tulsa, Houston, Toronto, London, Paris

M W KELLOGG — SUBSIDIARY OF PULLMAN INCORPORATED

EXCAVATION VOLUMES IN TRENCHES, ETC., CU. YD. PER 1000 LINEAL FT.

Depth of trench, in.	Width of trench, in.																					
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	18.5	24.7	30.9	37.0	43.2	49.4	55.6	61.7	67.9	74.1	80.2	86.4	92.6	98.8	105.	111.	117.	123.	130.	136.	142.	148.
14	21.6	28.8	36.0	43.2	50.4	57.6	64.8	72.0	79.2	86.4	93.6	101.	108.	115.	122.	130.	137.	144.	151.	158.	166.	173.
16	24.7	32.9	41.2	49.4	57.6	65.8	74.1	82.3	90.5	98.8	107.	115.	123.	132.	140.	148.	156.	165.	173.	181.	189.	198.
18	27.8	37.0	46.3	55.6	64.8	74.1	83.3	92.6	102.	111.	120.	130.	139.	148.	157.	167.	176.	185.	194.	204.	213.	222.
20	30.9	41.1	51.4	61.7	72.0	82.3	92.6	103.	113.	123.	134.	144.	154.	165.	175.	185.	195.	206.	216.	226.	237.	247.
22	33.9	45.3	56.6	67.9	79.2	90.5	102.	113.	124.	136.	147.	158.	170.	181.	192.	204.	215.	226.	238.	249.	260.	272.
24	37.0	49.4	61.7	74.1	86.4	98.8	111.	123.	136.	148.	160.	173.	185.	198.	210.	222.	235.	247.	259.	272.	284.	296.
26	40.1	53.5	66.9	80.2	93.6	107.	120.	134.	147.	160.	174.	187.	201.	214.	227.	241.	254.	267.	281.	294.	308.	321.
28	43.2	57.6	72.0	86.4	101.	115.	130.	144.	158.	173.	187.	202.	216.	230.	245.	259.	274.	288.	302.	317.	331.	346.
30	46.3	61.7	77.2	92.6	108.	123.	139.	154.	170.	185.	201.	216.	231.	247.	262.	278.	293.	309.	324.	340.	355.	370.
32		65.8	82.3	98.8	115.	132.	148.	165.	181.	198.	214.	230.	247.	263.	280.	296.	313.	329.	346.	362.	379.	395.
34		69.9	87.4	105.	122.	140.	157.	175.	192.	210.	227.	245.	262.	280.	297.	315.	332.	350.	367.	385.	402.	420.
36		74.1	92.6	111.	130.	148.	167.	185.	204.	222.	241.	259.	278.	296.	315.	333.	352.	370.	389.	407.	426.	444.
38		78.2	97.7	117.	137.	156.	176.	195.	215.	235.	254.	274.	293.	313.	332.	352.	371.	391.	410.	430.	450.	469.
40		82.3	103.	123.	144.	165.	185.	206.	226.	247.	267.	288.	309.	329.	350.	370.	391.	412.	432.	453.	473.	494.
42			108.	130.	151.	173.	194.	216.	238.	259.	281.	302.	324.	346.	367.	389.	410.	432.	454.	475.	497.	519.
44			113.	136.	158.	181.	204.	226.	249.	272.	294.	317.	340.	362.	385.	407.	430.	453.	475.	498.	521.	543.
46			118.	142.	166.	189.	213.	237.	260.	284.	308.	331.	355.	379.	402.	426.	450.	473.	497.	521.	544.	568.
48			123.	148.	173.	198.	222.	247.	272.	296.	321.	346.	370.	395.	420.	444.	469.	494.	519.	543.	568.	593.
50			129.	154.	180.	206.	231.	257.	283.	309.	334.	360.	386.	412.	437.	463.	489.	514.	540.	566.	592.	617.
52				160.	187.	214.	241.	267.	294.	321.	348.	374.	401.	428.	455.	481.	508.	535.	562.	588.	615.	642.
54				167.	194.	222.	250.	278.	306.	333.	361.	389.	417.	444.	472.	500.	528.	556.	583.	611.	639.	667.
56				173.	202.	230.	259.	288.	317.	346.	374.	403.	432.	461.	490.	519.	547.	576.	605.	634.	663.	691.
58				179.	209.	239.	268.	298.	328.	358.	388.	418.	448.	477.	507.	537.	567.	597.	627.	656.	686.	716.
60				185.	216.	247.	278.	309.	339.	370.	401.	432.	463.	494.	525.	556.	586.	617.	648.	679.	710.	741.
62					223.	255.	287.	319.	351.	383.	415.	446.	478.	510.	542.	574.	606.	638.	670.	702.	734.	765.
64					230.	263.	296.	329.	362.	395.	428.	461.	494.	527.	560.	593.	626.	658.	691.	724.	757.	790.
66					238.	272.	306.	339.	373.	407.	441.	475.	509.	543.	577.	611.	645.	679.	713.	747.	781.	815.
68					245.	280.	315.	350.	385.	420.	455.	490.	525.	560.	595.	630.	665.	700.	735.	770.	805.	840.
70					252.	288.	324.	360.	396.	432.	468.	504.	540.	576.	612.	648.	684.	720.	756.	792.	828.	864.
72						296.	333.	370.	407.	444.	481.	519.	556.	593.	630.	667.	704.	741.	778.	815.	852.	889.
74						305.	343.	381.	419.	457.	495.	533.	571.	609.	647.	685.	723.	761.	799.	837.	876.	914.
76						313.	352.	391.	430.	469.	508.	547.	586.	626.	665.	704.	743.	782.	821.	860.	899.	938.
78						321.	361.	401.	441.	481.	522.	562.	602.	642.	682.	722.	762.	802.	843.	883.	923.	963.
80						329.	370.	411.	453.	494.	535.	576.	617.	658.	700.	741.	782.	823.	864.	905.	947.	988.
82							380.	422.	464.	506.	548.	591.	633.	675.	717.	759.	801.	844.	886.	928.	970.	1010.
84							389.	432.	475.	518.	562.	605.	648.	691.	735.	778.	821.	864.	907.	951.	994.	1040.
86							398.	442.	487.	531.	575.	619.	664.	708.	752.	796.	841.	885.	929.	973.	1020.	1060.
88							407.	453.	498.	543.	588.	634.	679.	724.	770.	815.	860.	905.	951.	996.	1040.	1090.

Earth and clay increase in bulk ¼ when dug, but subside 1/5 in height and decrease 1/6 in bulk when formed into embankments.
Sand and gravel increase in bulk 1/12 when dug; sand subsides in embankment ¼ in height; gravel from 1/10 to 1/12 according to coarseness. Rock increases ½ of its original bulk when excavated.

APPROXIMATE WEIGHT OF EARTHS, ROCKS, ETC., LB. PER CU. YD.

Sand	3000
Gravel	3000
Mud	2500
Marl	2600
Clay	3100
Chalk	3600
Sandstone	3900
Shale	4000
Quartz	4100
Granite	4200
Trap	4200
Slate	4300

QUANTITIES OF EARTH EQUAL TO A TON (as filled into trucks)

	Volume, cu. ft.	Volume, cu. yd.
River sand	21	0.78
Pit sand	22	0.81
Coarse gravel	23	0.85
Marl	28	1.04
Stiff clay	28	1.04
Lump chalk	29	1.07
Earth	33	1.22

NATURAL SLOPES OF EARTH

	Avg. angle with horizontal
Gravel	40°
Dry sand	38°
Sand	22°
Vegetable earth	28°
Compact earth	50°
Shingle	39°
Rubble	45°
Clay, well drained	45°
Clay, wet	16°

LIGHT

...but what a Lift!

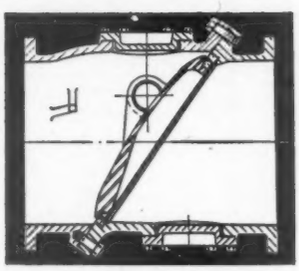
...that's the secret of this All-Time Low in Head Loss...

Take a close look at that Tilting Disc. See the special Aerofoil design that means light weight... and minimum resistance to flow in the open position.

Look again, and see how this Tilting Disc... pivoted just above center... is practically balanced, so is easily held open... and then cushions quietly to a drop-tight seat. This means no slamming under usual piping arrangements, no opening of pipe joints, no wear of valve parts.

And it means 65% to 85% less head-loss than with regular swing-type check valves. *Send for proof*... check the certified flow charts in Chapman's Bulletin No. 30. Write for a copy to:

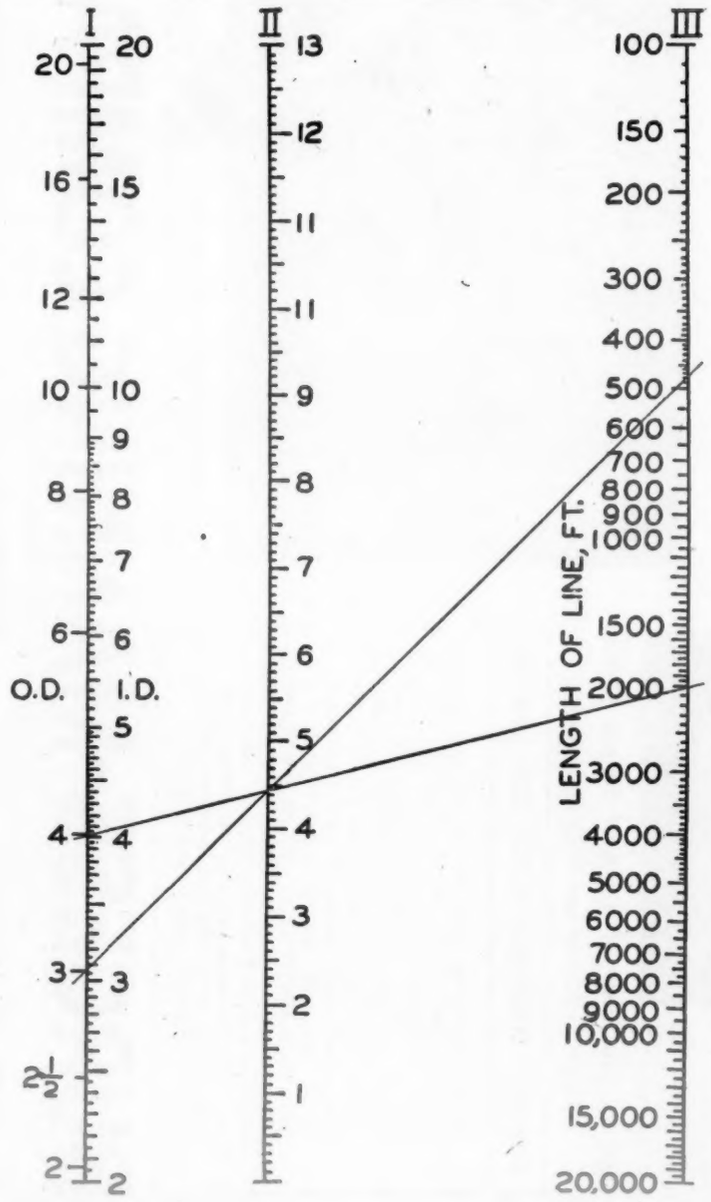
The Chapman Valve Mfg. Co., Indian Orchard, Mass.



Cross-section of the Chapman Tilting-Disc Check Valve. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

CHAPMAN TILTING DISC **CHECK VALVES**

SOLUTION OF COMPLEX PIPE LINE FORMULAS FOR GAS FLOW



The alignment chart on the left was constructed from the following formula:

$$L_1 = L_2\left(\frac{L_1}{L_2}\right)^{\frac{1}{n}}$$

Where:

L = length of the line in ft. and

d = diameter of the pipe in in.

Problem: What length of 4-in. diameter pipe will have the same pressure drop as 480 ft. of 3-in. diameter pipe?

Solution: Draw a straight line from the 3-in. pipe diameter on column I to 480 ft. length on column III. The line will intersect column II at 4.45. Then draw a straight line from the 4-in. diameter pipe on column I through 4.45 on column II which will intersect column III at 2000. The length of 4-in. pipe that will have the same pressure drop as 480 ft. of 3-in. pipe is 2000 ft.

In solving similar problems on this chart either internal diameter or external diameter may be used, although care must be taken to use one or the other for both pipes.

The alignment chart on the right side of the page was made from the following formula:

$$d_1 = d_2\left(\frac{d_1}{d_2}\right)^{5.33}$$

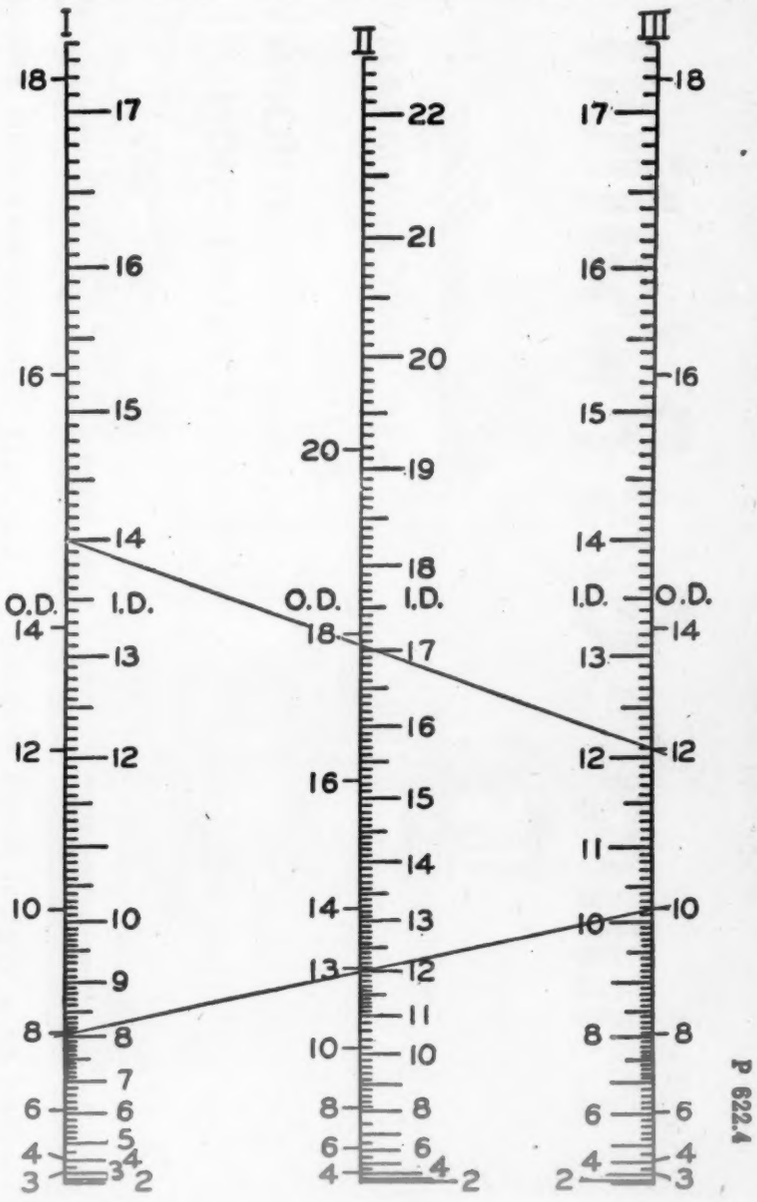
Where:

L = length of the line in ft. and

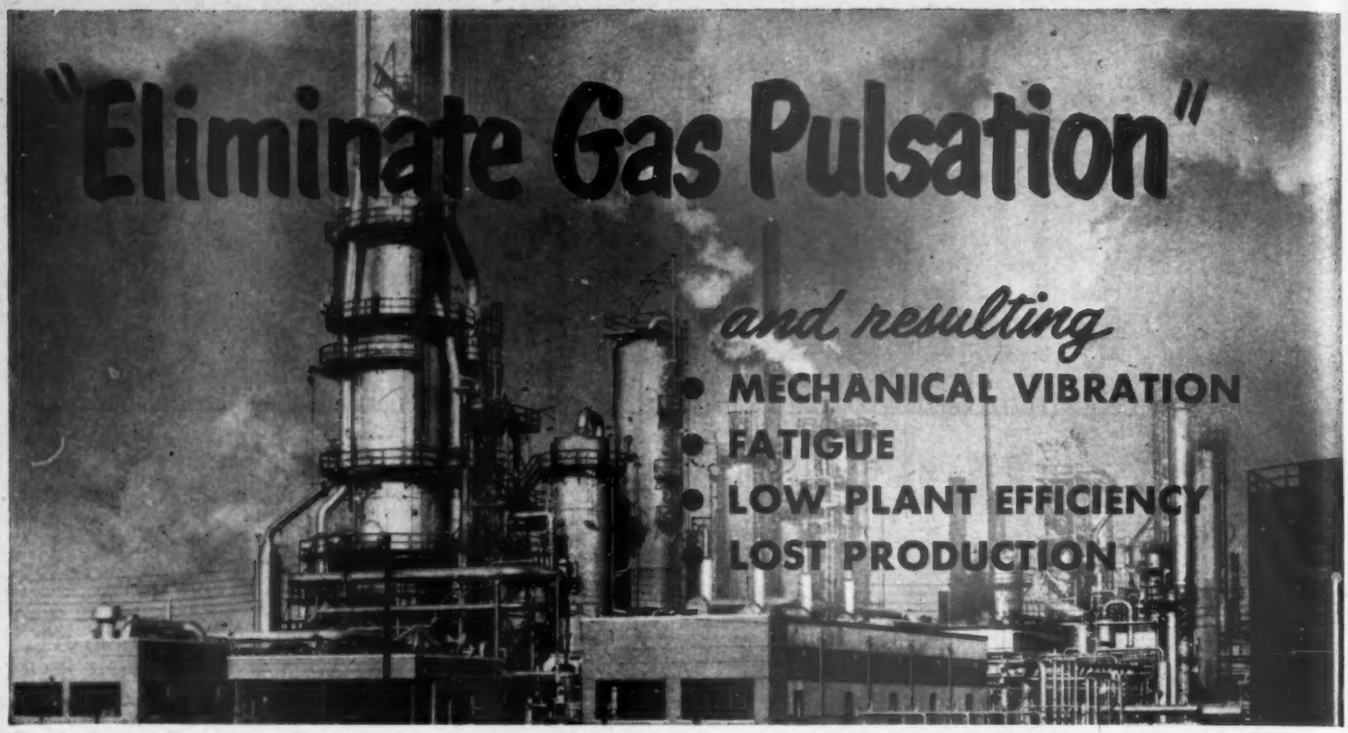
d = diameter of the pipe in in.

Problem: If an 8-in. and 10-in. external diameter pipe line parallel each other and are connected at each end, what size pipe would have the same capacity as both. (Note: Both sides of the looped lines must be the same length.)

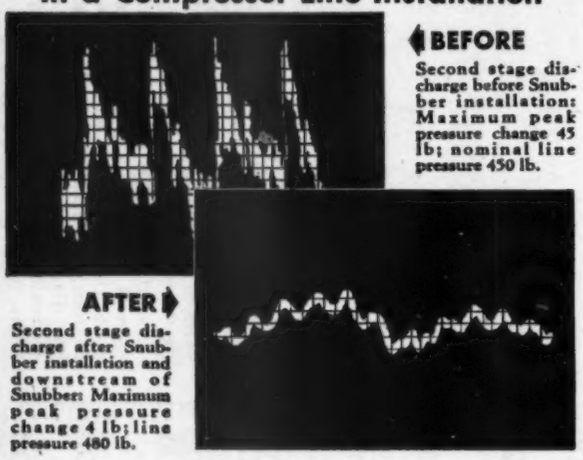
Solution: Draw a straight line from 8 on Column I to 10 on column III. The line will intersect column II at 13, which is the external diameter of a single pipe of equivalent capacity of the 8- and 10-in. lines.



P 622.4



Solution to a typical Surge Problem in a Compressor Line Installation



BEFORE

Second stage discharge before Snubber installation: Maximum peak pressure change 45 lb; nominal line pressure 450 lb.

AFTER

Second stage discharge after Snubber installation and downstream of Snubber: Maximum peak pressure change 4 lb; line pressure 480 lb.

Send for your copy of a typical Burgess-Manning Pulsation Survey and Analysis Report

BURGESS-MANNING PULSATION SURVEY

Burgess-Manning pulsation surveys are conducted by trained and fully experienced engineers with electronic equipment including pressure pickup (transducer), amplifier, and oscilloscope. The pressure transducer is coupled as close to the gas stream as possible and faithfully reproduces in voltage the pressure changes in the pipe. This voltage is conducted to a three stage amplifier and then to the oscilloscope screen. Photographs are taken of the screen as a record of surge. Data is taken and recorded. Maximum peak pressure change is calculated. Report is prepared. Recommendations are made that best solve your problems.

CONSULT BURGESS-MANNING ENGINEERS

Gas pulsation in compressor piping systems often results in excessive vibration and material fatigue. This, in turn, necessitates constant maintenance in piping and equipment resulting in lower over-all plant efficiency.

Your compressor system pulsation problem can be solved by Burgess-Manning Company engineers. This division maintains a field service to make surveys and analyses of flow conditions in pressure piping. Trained engineers correlate this data for reference in making Burgess-Manning Gas and Air Line Snubber recommendations for new plants as well as for existing plants.

Write for your copy of a typical case history in which Burgess-Manning engineers solved a tough problem.

Typical application showing Burgess-Manning Gas and Air Line Snubbers installed on discharge side of multiple-stage gas compressors.

Burgess-Manning Gas & Air Line Snubber.

BURGESS-MANNING COMPANY

1203 Dragon Street

Chicago, Illinois **DALLAS, TEXAS** **Libertyville, Illinois**

REPRESENTATIVES: Houston • Tulsa • Los Angeles • St. Louis • New York

STATIC PRESSURES, LB. PER SQ. IN. ABS., CORRESPONDING TO L-10 CHART READINGS

L-10 Chart Reading, P_L	Range of static pressure element, lb. per sq. in. (R_S)										
	50	100	250	500	1000	1500	2000	2500	3000	4000	5000
1.0	0.500	1.000	2.500	5.00	10.00	15.00	20.00	25.00	30.00	40.00	50.0
1.5	1.125	2.250	5.625	11.25	22.50	33.75	45.00	56.25	67.50	90.00	112.5
2.0	2.000	4.000	10.00	20.00	40.00	60.00	80.00	100.0	120.0	160.0	200.0
2.5	3.125	6.25	15.63	31.25	62.50	93.75	125.0	156.3	187.5	250.0	312.5
3.0	4.500	9.000	22.50	45.00	90.00	135.0	180.0	225.0	270.0	360.0	450.0
.1	4.805	9.160	24.03	48.05	96.10	144.2	192.2	240.3	288.3	384.4	480.5
.2	5.120	10.24	25.60	51.20	102.4	153.6	204.8	256.0	307.2	409.6	512.0
.3	5.445	10.89	27.23	54.45	108.9	163.4	217.8	272.3	326.7	435.6	544.5
.4	5.780	11.56	28.90	57.80	115.6	173.4	231.2	289.0	346.8	462.4	578.0
3.5	6.125	12.25	30.63	61.25	122.5	183.8	245.0	306.3	367.5	490.0	612.5
.6	6.480	12.96	32.40	64.80	129.6	194.4	259.2	324.0	388.8	518.4	648.0
.7	6.845	13.69	34.23	68.45	136.9	205.4	273.8	342.3	410.7	547.6	684.5
.8	7.220	14.44	36.10	72.20	144.4	216.6	288.8	361.0	433.2	577.6	722.0
.9	7.605	15.21	38.03	76.05	152.1	228.2	304.2	380.3	456.3	608.4	760.5
4.0	8.000	16.00	40.00	80.00	160.0	240.0	320.0	400.0	480.0	640.0	800.0
.1	8.405	16.81	42.03	84.05	168.1	252.2	336.2	420.3	504.3	672.4	840.5
.2	8.820	17.64	44.10	88.20	176.4	264.6	352.8	441.0	592.2	705.6	882.0
.3	9.245	18.49	46.20	92.45	184.9	277.4	369.8	462.3	554.7	739.6	924.5
.4	9.680	19.36	48.40	96.80	193.6	290.4	387.2	484.0	580.8	774.4	968.0
4.5	10.13	20.25	50.63	101.3	202.5	303.8	405.0	506.3	607.5	810.0	1013.
.6	10.58	21.16	52.90	105.8	211.6	317.4	423.2	529.0	634.8	846.4	1058.
.7	11.05	22.19	55.23	110.5	221.9	331.4	441.8	552.3	662.7	883.6	1105.
.8	11.52	23.04	57.60	115.2	230.4	345.6	460.8	576.0	691.2	921.6	1152.
.9	12.01	24.01	60.03	120.1	240.1	360.2	480.2	600.3	720.3	960.4	1201.
5.0	12.50	25.00	62.50	125.0	250.0	375.0	500.0	625.0	750.0	1000.	1250.
.1	13.01	26.01	65.03	130.1	260.1	390.2	520.2	650.3	780.3	1040.	1301.
.2	13.52	27.04	67.60	135.2	270.4	405.6	540.8	676.0	811.2	1082.	1352.
.3	14.05	28.09	70.23	140.5	280.9	421.4	561.8	702.3	842.7	1124.	1405.
.4	14.58	29.16	72.90	145.8	291.6	437.4	583.2	729.0	874.8	1166.	1458.
5.5	15.13	30.25	75.63	151.3	302.5	453.8	605.0	756.3	907.5	1210.	1513.
.6	15.68	31.36	78.40	156.8	313.6	470.4	627.2	784.0	940.8	1254.	1568.
.7	16.25	32.49	81.23	162.5	324.9	487.4	649.8	812.3	974.7	1300.	1625.
.8	16.82	33.64	84.10	168.2	336.4	504.6	672.8	841.0	1009.	1346.	1682.
.9	17.41	34.81	87.03	174.1	348.1	522.2	696.2	870.3	1044.	1392.	1741.
6.0	18.00	36.00	90.00	180.0	360.0	540.0	720.0	900.0	1080.	1440.	1800.
.1	18.61	37.21	93.03	186.1	372.1	558.2	744.2	930.3	1116.	1488.	1861.
.2	19.22	38.44	96.10	192.2	384.4	576.6	768.8	961.0	1153.	1538.	1922.
.3	19.85	39.69	99.23	198.5	396.9	595.4	793.8	992.3	1191.	1588.	1985.
.4	20.48	40.96	102.4	204.8	409.6	614.4	819.2	1024.	1229.	1638.	2048.
6.5	21.13	42.25	105.6	211.3	422.5	633.8	845.0	1056.	1268.	1690.	2113.
.6	21.78	43.56	108.9	217.8	435.6	653.4	871.2	1089.	1307.	1742.	2178.
.7	22.45	44.89	112.2	224.5	448.9	673.4	897.8	1122.	1347.	1796.	2245.
.8	23.12	46.24	115.6	231.2	462.4	693.6	924.8	1156.	1387.	1850.	2312.
.9	23.81	47.61	119.0	238.1	476.1	714.2	952.2	1190.	1428.	1904.	2381.
7.0	24.50	49.00	122.5	245.0	490.0	735.0	980.0	1225.	1470.	1960.	2450.
.2	25.92	51.84	129.6	259.2	518.4	777.6	1037.	1296.	1555.	2074.	2592.
.4	27.38	54.76	136.9	273.8	547.6	821.4	1095.	1369.	1643.	2190.	2738.
.6	28.88	57.76	144.4	288.8	577.6	866.4	1155.	1444.	1733.	2310.	2888.
.8	30.42	60.84	152.1	304.2	608.4	912.6	1217.	1521.	1825.	2434.	3042.
8.0	32.00	64.00	160.0	320.0	640.0	960.0	1280.	1600.	1920.	2560.	3200.
.2	33.62	67.24	168.1	336.2	672.4	1009.	1345.	1681.	2017.	2690.	3362.
.4	35.28	70.56	176.4	352.8	705.6	1058.	1411.	1764.	2117.	2822.	3528.
.6	36.98	73.96	184.9	369.8	739.6	1109.	1479.	1849.	2219.	2958.	3698.
.8	38.72	77.44	193.6	387.2	774.4	1162.	1549.	1936.	2323.	3098.	3872.
9.0	40.50	81.00	202.5	405.0	810.0	1215.	1620.	2025.	2430.	3240.	4050.
.2	42.32	84.64	211.6	423.2	846.4	1270.	1693.	2116.	2539.	3386.	4232.
.4	44.18	88.36	220.9	441.8	883.6	1325.	1767.	2209.	2651.	3534.	4418.
.6	46.08	92.16	230.4	460.8	921.6	1382.	1843.	2304.	2765.	3686.	4608.
.8	48.02	96.04	240.1	480.2	960.4	1441.	1921.	2401.	2881.	3842.	4802.
10.0	50.00	100.0	250.0	500.0	1000.	1500.	2000.	2500.	3000.	4000.	5000.

Inasmuch as square root (L-10) charts do not record pressures in lb. per sq. in. directly, it is necessary to resort to the following formula to convert the L-10 readings to lb. per sq. in. (absolute):

$$P_A = P^2_L R_S \div 100$$

where: P_A = static pressure, lb. per sq. in. (abs.)
P_L = static pressure reading on (L-10) chart
R_S = range of static pressure element

To convert P_A to gauge pressure, subtract the atmospheric pressure in vicinity from above values of P_A.

Deduct atmospheric pressure in comparing meter reading with indicating gauge reading.

ASK THE AEROFIN MAN

For the Practical Answer to Your Heat-Exchange Problem . . .

Aerofin is sold only by manufacturers of nationally advertised fan system apparatus. List on request.

There is a competent Aerofin heat-transfer engineer near you, qualified by intensive training and long experience to find the *right* answer to your own particular heat-exchange problem.

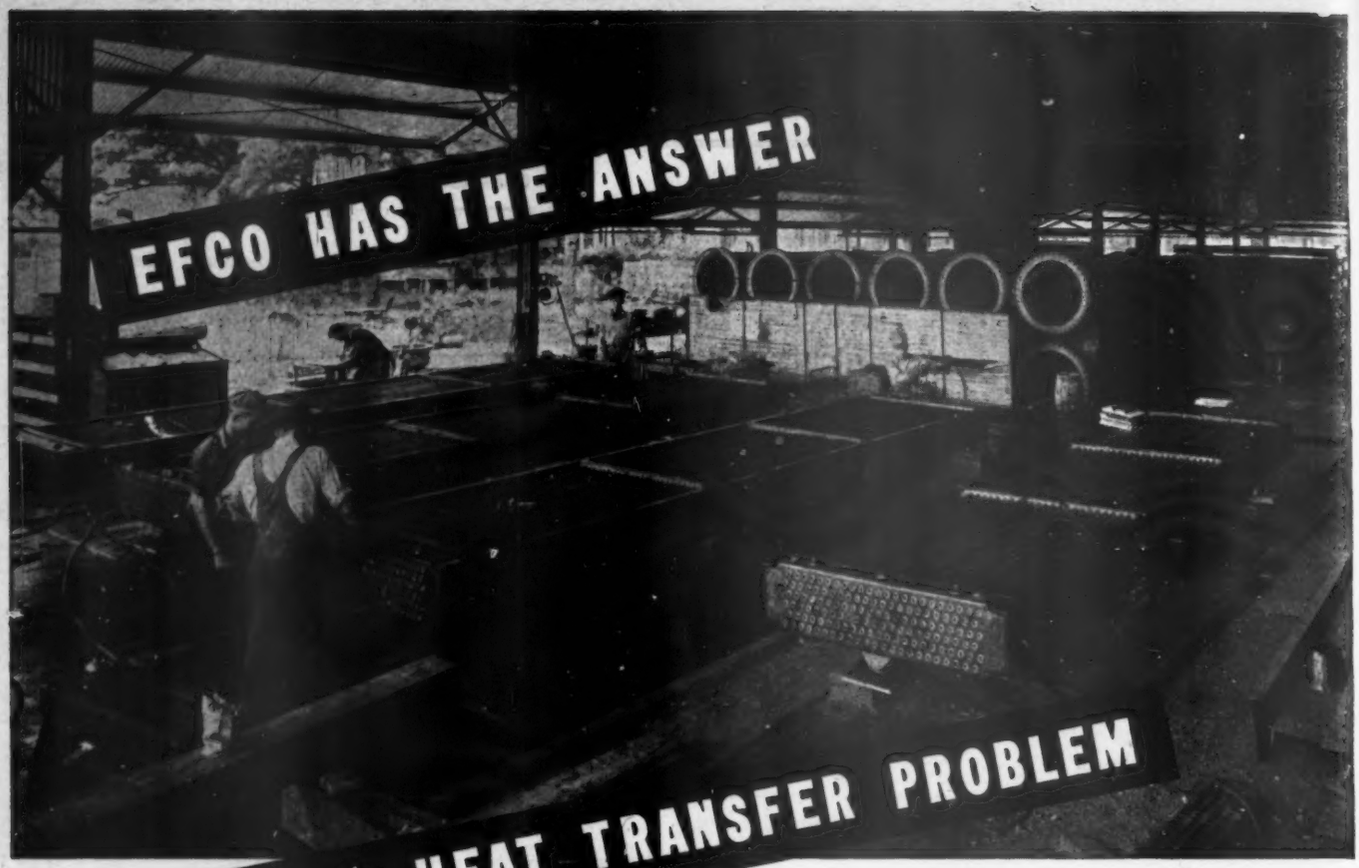
This specialized knowledge is there, ready for you to use to your greatest advantage. Ask the Aerofin man — and be right.

AEROFIN CORPORATION

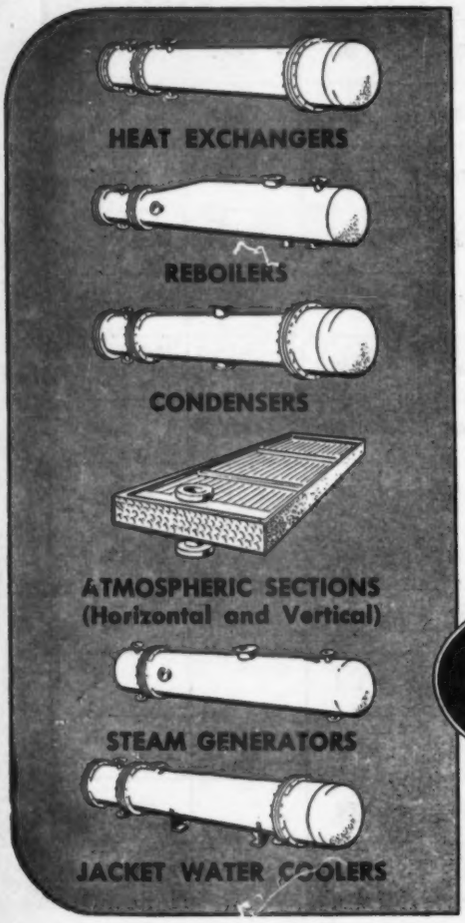
410 South Geddes St., Syracuse 1, N. Y.

PROPERTIES OF CONSTITUENTS OF NATURAL GASOLINE

Property	Constituent						
	Ethane	Propane	Butane	Iso-butane	Pentane	Iso-pentane	Hexane
Empirical formula	C_2H_6	C_3H_8	C_4H_{10}	C_4H_{10}	C_5H_{12}	C_5H_{12}	C_6H_{14}
Molecular weight	30.05	44.06	58.08	58.08	72.10	72.10	86.11
Specific gravity of gas (A=1)	1.038	1.523	2.007	2.007	2.491	2.491	2.976
Density, gas, lb. per cu. ft.	0.07949	0.11656	0.15365	0.15365	0.19074	0.19074	0.22780
Cu. ft. gas per lb.	12.579	8.579	6.508	6.508	5.243	5.243	4.390
Cu. ft. gas per gal. liquid	39.41	36.42	31.62	30.59	27.58	27.32	24.26
Specific gravity of liquid	0.3758	0.5092	0.5827	0.5637	0.631	0.625	0.663
A. P. I. gravity of liquid	249	146	111	120	93	95	82
Lb. per gal. liquid	3.133	4.245	4.858	4.700	5.261	5.211	5.527
Gal. per lb. liquid	0.319	0.236	0.206	0.213	0.190	0.192	0.181
Boiling point, deg. fahr.	—127.5	—44	30.9	10.0	97.0	82.4	156.0
Melting point, deg. fahr.	—278	—310	—211	—229	—204	—256	—138
Critical temp., deg. fahr.	90	207	304	273	387	370	455
Critical pressure, lb. per sq. in.	723	654	542	536	486	484	435
Specific heat of gas, C_p, B.t.u./lb.	0.505	0.473	0.456	0.462	0.448	0.448	0.442
Specific heat of gas, C_p, B.t.u./cu. ft.	0.0406	0.0566	0.0728	0.0731	0.0854		0.1006
C_p/C_v	1.22	1.13	1.108	1.110			
Heat of vaporization, B.t.u. per lb.	210	182	164	158	154	158	143
Heat of vaporization, B.t.u. per gal.	658	773	797	743	810	823	790
Heating value, B.t.u. per cu. ft. gas	1,795	2,580	3,350	3,266	4,007	4,012	4,730
Heating value, B.t.u. per lb.	21,990	21,300	20,900	20,800	20,900	21,100	20,800
Heating value, B.t.u. per gal. liquid	68,600	90,400	101,500	97,800	109,900	109,900	115,000
Lower inflammability limit, %	3.2	2.3	1.9	1.9	1.4		
Upper inflammability limit, %	12.5	9.5	8.5	8.4	8.0		
Mean coefficient of expansion, 0°—50° F.	.0028	.00143	.00096	.00113	.00081		.00070
Mean coefficient of expansion, 50°—100° F.		.00180	.00113	.00128	.00089		.00078

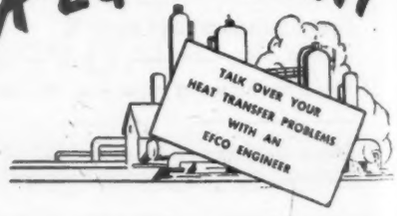


If your problem is the poor performance or high maintenance cost of your heat transfer units, consult an EFCO engineer. He will help you decide the changes or modifications necessary to get the desired performance from your heat transfer equipment.
Backed by knowledge and experience, EFCO engineers are constantly working to produce heat transfer units that will give efficient performance and long, trouble-free operation.



ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

EFCO
HEAT TRANSFER EQUIPMENT



CORRECTIONS TO CONVERT UNCORRECTED VAPOR PRESSURES TO REID VAPOR PRESSURES

Initial air temperature, deg. fahr.	Corrections in lb. per sq. in. for various temperatures as calculated for normal barometric pressures of:				
	760 mm.	745 mm.	700 mm.	650 mm.	600 mm.
32	−2.9	−2.9	−2.7	−2.6	−2.5
34	−2.8	−2.8	−2.6	−2.5	−2.4
36	−2.8	−2.7	−2.5	−2.4	−2.3
38	−2.7	−2.7	−2.5	−2.3	−2.2
40	−2.6	−2.6	−2.4	−2.3	−2.2
42	−2.5	−2.5	−2.4	−2.2	−2.1
44	−2.5	−2.5	−2.3	−2.2	−2.1
46	−2.4	−2.4	−2.3	−2.1	−2.0
48	−2.3	−2.3	−2.2	−2.1	−2.0
50	−2.2	−2.2	−2.1	−2.0	−1.9
52	−2.1	−2.1	−2.0	−1.9	−1.9
54	−2.0	−2.0	−1.9	−1.8	−1.8
56	−2.0	−2.0	−1.9	−1.7	−1.7
58	−1.9	−1.9	−1.8	−1.7	−1.7
60	−1.8	−1.8	−1.7	−1.6	−1.6
62	−1.8	−1.8	−1.7	−1.6	−1.6
64	−1.7	−1.7	−1.6	−1.5	−1.5
66	−1.6	−1.6	−1.5	−1.4	−1.4
68	−1.5	−1.5	−1.4	−1.3	−1.3
70	−1.4	−1.4	−1.3	−1.3	−1.2
72	−1.3	−1.3	−1.3	−1.2	−1.2
74	−1.3	−1.3	−1.2	−1.2	−1.1
76	−1.2	−1.2	−1.1	−1.1	−1.1
78	−1.1	−1.1	−1.1	−1.0	−1.0
80	−1.0	−1.0	−1.0	−0.9	−0.9
82	−0.9	−0.9	−0.9	−0.9	−0.8
84	−0.8	−0.8	−0.8	−0.8	−0.7
86	−0.7	−0.7	−0.7	−0.7	−0.6
88	−0.6	−0.6	−0.6	−0.6	−0.5
90	−0.5	−0.5	−0.5	−0.5	−0.5
92	−0.4	−0.4	−0.4	−0.4	−0.4
94	−0.3	−0.3	−0.3	−0.3	−0.3
96	−0.2	−0.2	−0.2	−0.2	−0.2
98	−0.1	−0.1	−0.1	−0.1	−0.1
100	−0.0	−0.0	−0.0	−0.0	−0.0
102	+0.1	+0.1	+0.1	+0.1	+0.1
104	+0.2	+0.2	+0.2	+0.2	+0.2
106	+0.3	+0.3	+0.3	+0.3	+0.3
108	+0.5	+0.5	+0.4	+0.4	+0.4
110	+0.6	+0.6	+0.5	+0.5	+0.5

From Natural Gasoline Supply Men's Association 1937 Handbook.

LAUGH with BARNEY

There was a young lady named Etta,
Who was fond of wearing a tight sweater;
Three reasons she had;
To keep warm wasn't bad—
But the other two reasons were better.

Recent surveys show that four out of five women haters are women!

Too many of us are like the old Negro deacon who wound up a long prayer by saying, "Use me, O Lord, use me in thy work—'specially in an advisory capacity."

Two citizens of an Iron Curtain country were riding on a streetcar. Suddenly one turned to the other and asked: "Tell me, Comrade, is tuberculosis fatal?" "Never mind,' replied the other, "he hasn't got it."

In a kindergarten class, the flags of various countries were being shown.

"What flag is this?" asked the instructor.

"This is the flag of my country," answered a bright little tot.

"And what is the name of your country?" was the next question.

" 'Tis of Thee," came the prompt reply.

Sign in nightclub: "Please do not stand up while room is in motion."

A trip upstairs alone at night was a fearful mission for little four-year-old Tommy. "Don't be afraid," his mother comforted him, "God will be with you." As he crept up the stairway and reached the top he was overheard to pray, "Oh, God, if you're up here, please don't move or you'll scare me to death!"

On answering his doorbell a man found an old friend and a large dog standing on his porch.

"Come in! Come in!" he said.

His friend came in and sat down, while the dog put the man's cat to flight, knocked over a bridge lamp and several vases, and finally made himself comfortable in his best chair.

When the guest rose to leave, the host said with a touch of sarcasm in his voice, "Aren't you forgetting your dog?"

"Dog? I have no dog. I thought he was yours."

Believe It Or Not: Adam and Eve invented the loose-leaf system.

Boy standing on the corner, asked the driver of a new stream-lined car: "Which way are you going?"

"What difference is it to you?"

"Well, I just wanted to cross the street."

A guy who takes a snort while driving may get a cop for a chaser.

YOU CAN'T GET UP TO GIVE THE BABY HIS BOTTLE - OH NO! BUT WHEN THAT PHONE RINGS FOR PERFORATING SERVICE - BOY! HOW YOU MOVE!
LANE-WELLS
CESOG

The handwriting of that most individual and picturesque Speaker of the House, the late "Uncle" Joe Cannon, was extremely illegible. Once Representative Cushman returned one of his communications with this comment: "Mr. Speaker, I got this letter from you yesterday and I couldn't read it. I showed it to twenty or thirty fellows in the House, and, between us, we spelled out all but the last three words."

Uncle Joe scrutinized the undecipherable conclusion, and then replied: "The last three words are 'Personal and Confidential'."

The Sunday school teacher had been telling a story of spring, and the miracle of the growth of the Easter lily.

"Now, children," she said, "who can tell me what it is that makes the lily spring from this little bulb?"

"God does it," said one little boy. Frantically Bobby raised his hand and shouted at the top of his lungs, "Fertilizer helps!"

A reporter was told to cut his stories to bare essentials. His next story read: "Q. Johnstone looked up the elevator shaft to see if the car was coming down. It was. Age 52."

A three-year-old boy cried bitterly as a large friendly dog bounded up to him, licking his hands and face. "What is it?" asked his mother. "Did he bite you?"

"No," came the reply, but he tasted me!"

A sign in a western town reads: "4029 people died of gas in this state last year. Two inhaled it; 27 put a lighted match to it; and 4000 stepped on it.

Boss: Get me Mr. Dill.
PBX Attendant: Is that B as in Bill?
Boss: No, D as in pickle.

A teacher, unfastening with difficulty the coat of one of her little pupils, asked: "Did your mother hook this coat for you?" "No," was the reply, "she bought it."

Four old cronies were seated around a table in the back room of the general store, apparently playing poker, as the sheriff entered.

"Gamblin' again, eh?" he accused.

"Not me, sheriff," one replied, "I just dropped in for some talkin'."

"You're playin'," the sheriff said to another.

"No, sir, sheriff," he replied. "I'm just here warmin' at the stove."

"What about you?" a third was asked.

"Not playin', sheriff, just visitin'," the old fellow said.

The fourth was holding cards in his hands, and the sheriff turned to him with a triumphant smile.

"Well, here's one who can't deny he's playin'," the sheriff said.

"Me playin', sheriff?" the old gent asked with a hurt look. "Who'd I be playin' with?"

BEAIRD
Ingersoll-Rand

Packaged Compressor Plant

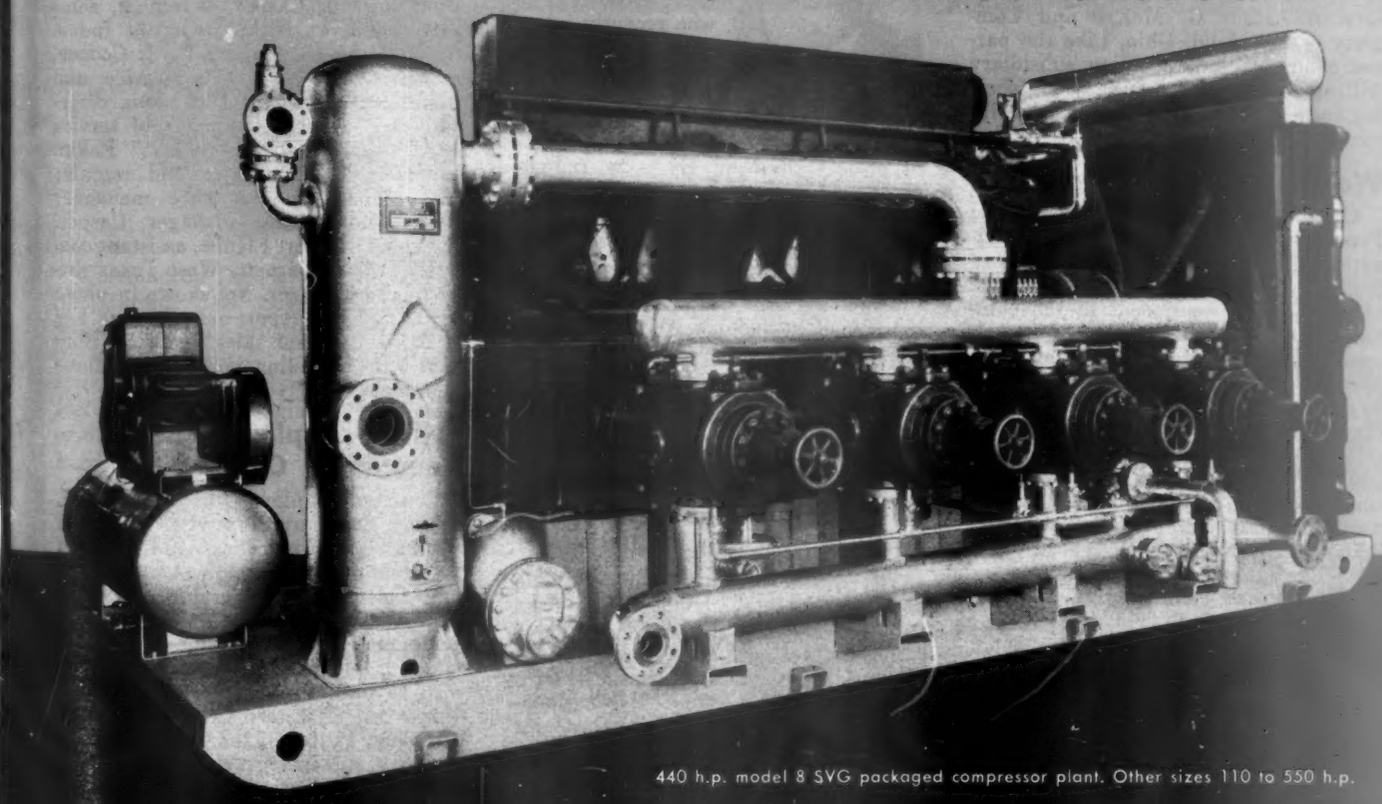
How Complete Packaging saved over 30% on installation cost of one compressor station

Actual comparative costs were made recently between a packaged compressor installation and a permanent type installation, for repressuring service in a Southwest field. With a requirement of approximately 3,000 horsepower, it was found that Beaird-Ingersoll-Rand packaged compressor plants could be installed for 30% less than the cost of a permanent compressor station.

The saving is achieved by centralized purchasing, fabricating and complete assembly at the factory, rather than by use of expensive field assembly. The cost of housing for operators was also avoided because automatic controls on the packaged units made regular attendants unnecessary.

An added economy will be afforded by packaged units in the future when the plant is expanded. The capacity of the plant may be increased by simply installing additional Beaird-Ingersoll-Rand packaged compressor plants, without expensive remodeling of the entire station.

Write for information on the economy of complete packaging.



440 h.p. model 8 SVG packaged compressor plant. Other sizes 110 to 550 h.p.

LEAST COST PER HORSEPOWER, INSTALLED

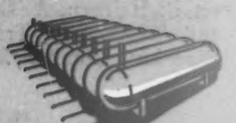
SINCE 1918 BEAIRD SHREVEPORT

THE J. B. BEAIRD COMPANY, INC. Shreveport, Louisiana

LP GAS SYSTEMS

CAST STEEL FITTINGS

ANHYDROUS AMMONIA EQUIPMENT



PRESSURE BULK STORAGE

OIL and GAS TRADE NEWS

Baash-Ross officials held a 3-day meeting in Odessa, Texas, recently at the company's newest plant.

Canadian Subsidiary Formed

H. E. Widdell, president of Arthur G. McKee and Company, engineers and contractors, has announced the opening of offices of the Canadian subsidiary, Arthur G. McKee and Company of Canada, Ltd., at 350 Bay Street, Toronto, Ontario. Ralph A. Westervelt has been appointed vice president to direct the operations of this office. The new Canadian engineering company, which was organized on July 2, 1952, is a subsidiary of Arthur G. McKee and Company of Cleveland, Ohio. Like the parent company, the Canadian subsidiary will specialize in the design, engineering and construction of petroleum facilities.

Warehouse Plant Leased

Caterpillar Tractor Company, of Peoria, Illinois, has announced the execution of a long-term lease for a warehouse and parts processing plant to be erected on land adjacent to the company's new plant site at York, Pennsylvania. The one-story structure to cover about 300,000 sq ft will be constructed by E & S Realty Company, Baltimore, Maryland. It will have an adjacent outside concrete storage slab of about 72,000 sq ft and ample parking space for employees. Caterpillar's 600,000 sq ft manufacturing plant, under construction on a 200-acre tract, is scheduled to begin into limited production about July 1953 and to be completed by the end of that year.

Cost Accountants Meet

The annual discussion forum of the National Association of Cost Accountants was held recently in the Ezekial Cullen Building at the University of Houston. General topic for discussion was "Taking Inventory of Inventory Practices." Among outstanding Houston accountants who led discussion groups were Jack P. Jones, Humble Oil and Refining Company, Baytown; Raymond Holliday, Hughes Tool Company; Robert B. Heinzen, A. O. Smith of Texas; and Art Cannon, Transcontinental Gas Pipe Line Company.

Ike Farley Heads Office Opened by Annin Company

A new office has been opened in Houston, Texas, by Annin Company of Los Angeles, well-known manufacturer of control valves for various industrial applications. The office will be under the management of Ike Farley, who recently joined the Annin organization. Farley comes to Annin from the Lummis Company of Houston where he held the position of project engineer. He is a graduate of Drexel Technical College, in Philadelphia, Pennsylvania.

Ike Farley

Page Announces Expansion

Page Oil Tool has recently doubled the size of its factory. Additional office space has been added and complete facilities for the manufacture of Page tubing anchors, oil and gas separators, tubing drains, packers, cementers, and hydraulic equipment provide increased production capacity.

BJ Appoints Representative For British West Indies

The appointment of Trinidad Oilfield Service, Ltd., 14 High Street, San Fernando Trinidad as agents for Oil Tool and PB Divisions, Byron Jackson Company, for the British West Indies, has recently been announced by B. A. Hilliard, general sales manager, Byron Jackson Company. George Kayne, general manager of Trinidad Oilfield Service, Ltd., recently completed a course of training at the BJ factories in Los Angeles. The appointment was effective July 1, 1952.

George Kayne

Baash-Ross Executives Meet At Odessa, Texas, Plant

Officials and directors of the Baash-Ross Tool Company recently completed a three-day meeting at the Odessa, Texas, plant, newest of the 17 major plants and service headquarters that Baash-Roos operates throughout the nation's oil industry.

Shown in the group photograph, front row; Bob Morris, assistant superintendent, West Texas gas division; Al Schoettler, Houston office manager; L. L. Garren, manager, West Texas division; Bill Noland, superintendent, Pampa, Texas, plant; W. J. Williams, general works manager; George Nordyke, manager, Olney, Illinois, division; Don Moorhausen, production control manager; H. "Ink" Wotkyns, vice president in charge of Mid-Continent division; Bill Wallace, Oklahoma City office manager. Standing are R. L. LeBus, Northern Mid-Continent district manager; C. E. Laws, Southern Mid-Continent district manager; A. F. Brown, vice president; F. L. Tooley, executive vice president; T. A. Boyd, secretary-treasurer; G. D. Johnson, vice president; E. M. Gearke, general sales manager; L. F. Baash, president; J. L. Dickmann, chief engineer; Don Bowcutt, Casper, Wyoming, sales representative; H. L. Richards, industrial relations manager; W. J. Cooper, manager Oklahoma City service and rentals; Dr. Richard Dickmann, director; O. A. Brown, manager of service and rental department; "Doc" Eakin, manager Odessa service and rentals; Jess Moody, Odessa office manager; Ralph Hall, district manager, Casper, Wyoming; Robert Flynne, assistant controller; J. L. Barnett, West Texas district sales manager. Not shown in photo are K. S. Ross, export manager and Lee J. Laird, assistant sales manager. Both men were attending company business elsewhere.

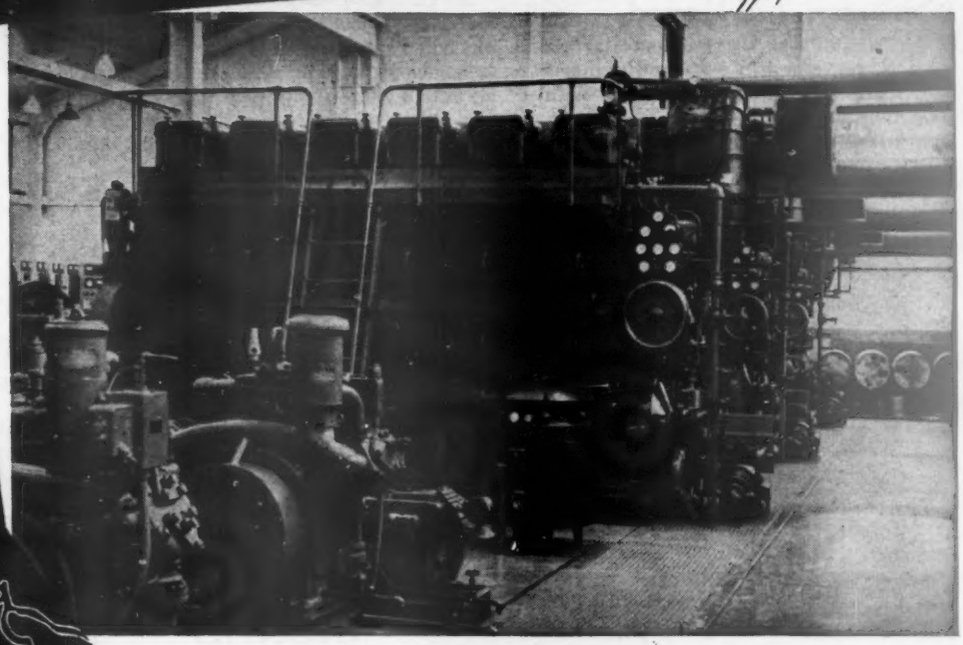
Kellogg Employees Are Honored at Club Dinner

Fourteen employees of The M. W. Kellogg Company, Jersey City designers and builders of petroleum and chemical processing plants, were honored recently at the company's annual Quarter Century Club dinner in New York City. Presentation of their awards brought the club membership to 137 employees with 25 or more years of service. The dinner was addressed by Champ Carry, president, Pullman, Inc., of which Kellogg is a subsidiary; Warren L. Smith, Kellogg president; and William Diener, Quarter Century Club president.

UOP Gets New Offices

Universal Oil Products Company has announced that its principal administrative and engineering offices are situated in the company's new building in Des Plaines, Illinois. Street Address is 30 East Algonquin Road.

How "TAPLINE" is powered to bring oil across SAUDI ARABIA



Some of the 40 Worthington Supercharged Diesels installed at five stations along Tapline, operated by the Trans-Arabian Pipeline Co. Other Worthington equipment on this project includes centrifugal refrigeration compressors for air conditioning.

Worthington Diesel Engines Selected In The Largest Single Peacetime Diesel Contract Ever Awarded

Worthington Diesels were the choice for "Tapline", the huge, recently completed engineering project that is carrying oil from the oil-rich Persian Gulf area across the Saudi Arabian Desert to the Mediterranean — bringing a vital commodity 3,500 miles and 10 days nearer to European markets.

Fueled by crude oil bled from the line, 40 Worthington Diesels, at five stations along the 1068-mile system, are an unfailing source of economical, trouble-free power. Their services include pumping oil through the line (over 13 million gallons daily), generating power for 10 centrifugal compressors used for air conditioning the maintenance quarters, for pumping tremendous quantities of water needed at each station, and for lighting the communities at the stations — each of which has electrical requirements equal to an American town of 7,000 population.

Everywhere In The World . . .

Worthington Diesels on pipeline duty and in many other services are proving that this company's pioneering in Diesel building and development pays off in better, lower-cost engine performance.

Write to Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Engine Division, Buffalo, N. Y.

SEE OUR CATALOG IN THE COMPOSITE CATALOG

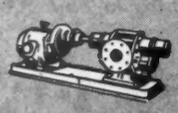
WORTHINGTON

YOUR PARTNER IN POWER PROGRESS

Diesel engines, 150 to 3,520 hp . . . gas engines, 175 to 3,520 hp...dual fuel engines, 225 to 3,290 hp.

WORTHINGTON-BUILT AUXILIARIES

Balanced Angle Compressors



Oil Transfer Pumps

Cooling Water Circulating Pumps

Evaporative Type Engine Water Cooler

Jefferies Changes Name

Jefferies Engineering Company of Westfield, New Jersey has changed its name to Engineering Corporation of America, as announced by Fitch B. Jefferies, president. The Corporation specializes in the designing and building of special mechanical and process equipment for the chemical and petrochemical process industries.

Distributors Are Named

A distributorship agreement has recently been signed by Service Engineering Company, Inc., Oklahoma, with Worthington Corporation. The Tulsa firm will handle Worthington's Multi-V-Drives and Allspeed Selectors.

Cenco to Handle Chemicals

Central Scientific Company has announced that the Mallinckrodt line of more than 400 analytical reagents will be the principal brand of laboratory chemicals offered to its customers. Warehouse facilities of Cenco's branches are being readied and stocked.

Georgia Branch Opened

A. O. Smith Corporation, meter division, has opened a new factory branch office at 1118 West Peachtree Street, Atlanta, Georgia. The new branch, which is under the direction of Thomas C. Ficken, is stocked with a complete line of SMITHway meters and service station pumps as well as repair parts.

McCarty Opens Chicago Office

Marking a third of a century of growth as an industrial advertising agency, The McCarty Company opened offices in Chicago, Illinois, at 20 East Huron Street on December 1. Long established as one of the country's leading technical agencies specializing in industrial products, McCarty operates offices in Los Angeles and San Francisco, California, and was founded in 1919. The Chicago office will be under the management of Harry L. Bauer, Chicago advertising counsellor.

H. L. Bauer

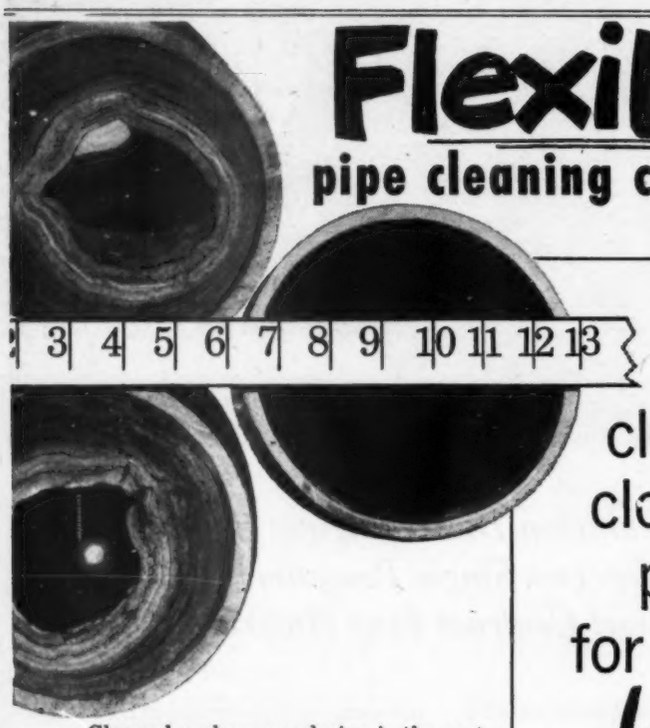
Marlow Pumps Expands

Marlow Pumps has put into operation a complete branch factory of 16,000 sq ft in De Queen, Arkansas. The new plant, situated in southwestern Arkansas, permits fast delivery to all sections of the southwestern U. S. The new factory will also carry a complete inventory of all Marlow pumps as well as replacement parts. Sales and engineering staffs have been enlarged and will use the new plant as a regional headquarters.

Shop on Wheels. Roy Coulter, field engineer for National Supply Company, recently designed a trailer, in which he carries his equipment directly to the rigs. His specialty is replacing tool joints on Spang Shrink thread drill pipe.

Water Treatment Engineers Meet in Dayton, Ohio

A Water Treatment Engineer's Meeting, sponsored by Dearborn Chemical Company, was held recently in Dayton, Ohio. Among the speakers participating in the meeting were H. O. Scott, Dearborn's Dayton representative; E. M. Welch, C. S. Silsbee, and C. C. Dennis, sales staff; and Dr. M. F. Obrecht, Professor of chemical engineering, Michigan State College.



Flexible
pipe cleaning company

3 4 5 6 7 8 9 10 11 12 13

cleans clogged pipe for about 1/30th the cost of replacement!

Guarantees 95% new pipe efficiency!

Clogged underground pipe is the costliest pipe you can own or operate! Every particle of scale and rust deposited on the pipe wall cuts capacity, skyrockets your pumping and operating costs.

You, no doubt, are considering *replacing* this clogged pipe. But before you consider pipe replacement, remember this – Flexible Pipe Cleaning Company can *clean* that clogged line – return it to guaranteed 95% efficiency – and AT A FRACTION OF REPLACEMENT COST! For example, new 10" steel line, 30" underground costs at least $6.00 per foot wrapped and laid. Tees and crosses are extra. Flexible can *clean* that SAME LINE FOR ABOUT 18¢ PER FOOT – *or 1/30th the cost of replacement!*

How much to clean your clogged lines? Send for our Preliminary Job Cost Estimate form. Take five minutes to complete this form and return it to us. We'll give you a free estimate on the cost of cleaning your pipe – stacked, stored or underground. Our crews are near you.

Write today for our Preliminary Job Cost Estimate form.

f-l-e-x-i-b-l-e pipe cleaning company

9324 So. Norwalk Blvd. Los Nietos, California
P.O. Box 167 OXford 5-5713

Waukesha Reports Record High Hit in Sales in 1951

The entire board of directors of the Waukesha Motor Company was re-elected at the annual meeting of Stockholders in Waukesha, Wisconsin recently. Also re-elected were officers, which included: J. E. DeLong, president; J. G. Swain, vice president; and C. P. Ross secretary and treasurer. Also confirmed by directors were the appointments by DeLong of C. E. Nelson, vice president for production, and L. W. Youker, assistant secretary and treasurer.

Report to the stockholders showed the company's sales were highest in its history, nearly $46,000,000.

Cleco Appoints Agents

The Cleco Division of the Reed Roller Bit Company, Houston, Texas, has announced the appointment of Electric Tool and Supply Company, 3000 Santa Fe Avenue, Los Angeles, California; Industrial Supplies Company, 324 North Seventh Street, Steubenville, Ohio; and Florida Aviation Corporation, 4051 N.W. 25th Street, Miami 42, Florida, as distributors for Cleco products in their areas.

IDECO Expands Facilities

George W. Walton, vice president of IDECO, Dresser Industries subsidiary, has announced that IDECO has arranged to manufacture and sell in this country the complete line of oil field equipment manufactured by Woodfield Hoist and Associated Industries, Ltd., of Rochester, England. Woodfield equipment incorporates in its manufacture a number of exclusive features that are expected to find ready acceptance in the American oil industry.

Walton, also announced that an exclusive export agreement has been signed with Hall-Scott Motor Division, ACF-Brill Motors Company for the world sales rights outside of continental United States for Hall-Scott industrial engines.

IDECO also is consolidating the Torrance, California, manufacturing facilities into those of the IDECO Beaumont, Texas, plant. Walton announced that this consolidation does not in any way affect the California IDECO sales or service organizations, which will continue to operate under the direction of C. F. Van Loozen.

Hough Company Becomes IHC Subsidiary Company

John L. McCaffrey, president of International Harvester Company, has announced that Harvester has acquired the stock of The Frank G. Hough Company of Libertyville, Illinois, making Hough a wholly owned subsidiary. "We will operate the Hough Company as a wholly owned subsidiary, with no immediate change in the organization of the company. We feel we are particularly fortunate in having Frank G. Hough continue as president of the subsidiary company, directing the activities of the business which he has built up," McCaffrey reported.

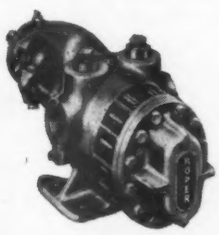
Worthington Consolidates Power Transmission Tools

Headquarters for the sales, engineering, and production of Multi-V-Drives and Allspeed Drives have been consolidated at the Oil City, Pennsylvania, plant of Worthington Corporation, according to an announcement by E. J. Schwanhausser, executive vice president. A new division to be known as the mechanical power transmission division has been set up to handle this equipment. Sales functions of the new division will be under the direction of D. E. Tessendorf, manager, and H. W. Kumro, assistant manager. Fred G. Moore has been named chief engineer of the division, and manufacture of these products will be under the direction of W. F. Weinreich, works manager of the Oil City plant.

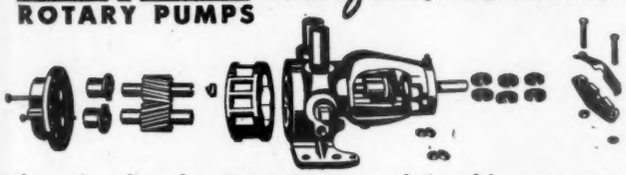
ECCO Is Incorporated

Officials of the Engineering Construction Company, pipe line contractors, recently announced the incorporation of that firm. The business was incorporated under the laws of Nevada and is a successor to the original partnership of Lee Vaughan and Russell D. May. Vaughan, president of the corporation, made the announcement and listed the officers of the firm as follows: Lee Vaughan, president; Curt Vaughan, vice president; H. H. Griffin, vice president and secretary; Eugene Monnet, assistant secretary and assistant treasurer; and John E. Baker, assistant secretary and treasurer.

Savings that Pay Off...



ROPER ROTARY PUMPS are quick to Service



Above view shows how Roper Pumps are designed for easy accessibility. Not necessary to disturb pipe connections or mountings.

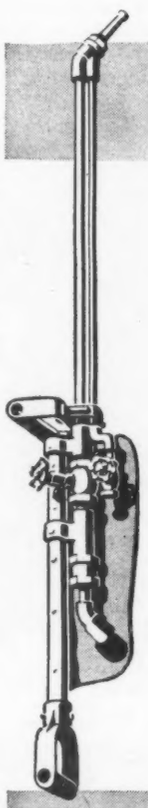
When an installation requires inspection because some destructive foreign element causes trouble, quick servicing design cuts down-time to a minimum and speeds the job. Furthermore, Roper replacement parts are interchangeable and available on all current models.

The exploded view above shows the detail of disassembly of a Roper Series F Pump . . . available for pressures up to 300 P.S.I. — built in 13 sizes up to 300 G.P.M.

Write for Catalog Today
Capacities to 300 g.p.m.
Pressures to 1000 p.s.i.
GEO. D. ROPER CORP.
732 Blackhawk Park Avenue
ROCKFORD, ILLINOIS

ROPER Rotary Pumps

Cut cleaning time in half



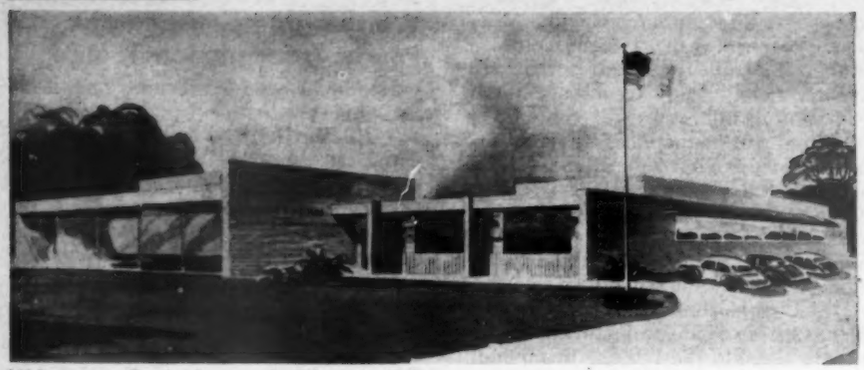
JUST hook this gun up to your snuffer lines — twist the valve to clean and rinse. One man with this dirt-dynamiter can clean up your plant in half the usual time.

Gun blasts away soil, even from hard-to-reach areas. Lifts cleaning spray up to 12 feet above working level. Tops for cleaning up around processing units, docks, salvage areas, machine shops, garages, power houses, pipe stills, decks, gridwalks, etc.

Try it yourself. Ask your Oakite Service Representative or write Oakite Products, Inc., 48 Rector St., N. Y. 6, N. Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
REG. U.S. PAT. OFF.
MATERIALS • METHODS • SERVICE

Technical Service Representatives in Principal Cities of U. S. & Canada



Midwestern Engine's new building in Tulsa.

E. O. Murrey

A. H. Bost

Glass Fibers Joins Group

Glass Fibers, Inc., has joined the Industrial Mineral Fiber Institute. The announcement was made jointly by officials of the company and by Frank Christenson, president of the Institute whose headquarter offices are at 441 Lexington Avenue, New York City. R. W. Capaul, vice president and general sales manager, and F. J. Solon, Jr., vice president — advertising and public relations attend association conferences.

Student-Aid Program

Commemorating 20 years of service to the oil industry, Lane-Wells Company has launched a comprehensive student-encouragement program, consisting of fellowships, scholarships, and technical paper contests. The program is open to undergraduate and graduate students of petroleum engineering currently attending a selected group of colleges in the United States and Canada. According to James D. Hughes, Lane-Wells general sales manager, the program is being undertaken in order to encourage students to advance themselves.

Sperry-Sun Office Moved

Sperry-Sun Well Surveying Company has moved its Falfurrias, Texas, district office to Corpus Christi, Texas. With this move, E. J. Blackburn, formerly of the Houston district, was promoted to district manager of the Southwest district, with his new headquarters at 319 Westchester Drive, Corpus Christi. Blackburn has been with Sperry-Sun Well Survey Company for 6½ years in the capacity of sales engineer. Blackburn is assisted by H. J. James, sales engineer and V. S. Mueck, salesman.

E. J. Blackburn

B. O. Dickerson, superintendent, right, for La Cuno Oil Corporation, instructs Ococie Williams, laborer, on the operation of a Mission Manufacturing Company plug valve at the La Cuno central separator and dehydration plant near Waskom, Texas. Incidentally, Ococie Williams' wife recently presented him with his 24th child.

Midwestern Engine Opens New Tulsa Building

Opening of the new home of Midwestern Engine and Equipment Company, Tulsa, Oklahoma, a national distributor of pipe line supplies and equipment, has been announced by E. O. Murrey, president. All facilities of the new building are under one roof, providing maximum coordination between departments. The modern one-story masonry and brick structure, situated at 4645 Sapulpa Road, Tulsa, utilizes plate glass and more than 18,000 sq ft of Fiberglas building products. The building is on an 11-acre site, providing room for future expansion. A parking lot for customers and employees on the south side of the building will accommodate 100 vehicles.

Officers of the firm are Murrey, president, and Armon H. Bost, vice president and secretary-treasurer. John W. Brand is sales manager, pipe line division, in the Tulsa office. J. W. McCray manages the Oklahoma City branch.

Expansion Plan Nears End

Pittsburgh Steel Company has announced it is nearing completion of its $60,000,000 modernization and product-addition program launched in August 1950. Molding of ingots at Monessen, Pennsylvania, for the Allenport pipe mill has been discontinued. The Pilger mill is being dismantled, and in its spot will be erected the cold finished sheet mill, giving the company the most important diversification of product in its history. Avery C. Adams, president, announced that the company expects to be producing hot rolled sheets by the end of the first quarter of 1953 and cold rolled sheets by the end of the second quarter of next year.

GM Distributors Build Corpus Christi Plant

Stewart and Stevenson Services, distributors of General Motors diesel engines, has announced the opening of its new and larger plant in Corpus Christi, Texas. The new building, a completely modern structure in the city's newest industrial district, provides for greatly expanded engine repair facilities as well as a proportionately increased stock of engine repair parts. The Corpus Christi plant is a branch of Stewart and Stevenson Services in Houston.

BIF Service Center Opens

BIF Industries has established a service center in Seattle, Washington, that is equipped to handle all service problems of Builders-Providence, Inc., flow meters and controllers and Omega Machine Company dry feeders. L. W. (Pete) Armstrong is in charge of Service, he holds a BS degree in chemical engineering and was associated with the firm of Cary-Kramer and Associates, Seattle, as design engineer.

L. W. Armstrong

Delanium Plant in Operation

W. J. Crawford, president of Delanium Carbon Corporation, a corporation jointly owned by Great Lakes Carbon Corporation and Powell Duffryn Carbon Products, Ltd., has announced that its new factory at Morton Grove, Illinois, went in production last month. The facilities of this specially designed plant will be used to produce Delanium graphite cubic heat exchangers.

Dow Representatives Named

Royston Laboratories, Inc., of Blawnox, Pennsylvania, manufacturers of protective coatings, have been named distributors for Dow magnesium anodes for the protection of underground and underwater structures, W. S. Loose, sales manager, magnesium department, The Dow Chemical Company, announced. Dow anodes to be distributed by Royston Laboratories include the cast magnesium anodes as well as the extruded ribbon sands, etc.

Engineering Award Program

The Rules and Conditions for the sixth annual competition of the Engineering Undergraduate Award Program have been released by the James F. Lincoln Arc Welding Foundation. The Rules for this year's competition have been changed in a number of important respects:

1. The 46 awards to be made will be for the best designs of a machine or any part thereof signed for welded construction. 2. Duplicate awards will be made for the best entries in both mechanical design and structural design. 3. All entries will be limited to no more than 20 pages. The Rules and Conditions booklet is now available from Lincoln Foundation, Cleveland 17, Ohio.

Dearborn 25-Year Club

Dearborn Chemical Company held its fourth annual 25-year Club dinner at the House on the roof of the Hotel Sherman recently, in Chicago, Illinois. The dinner was attended by 30 Dearborn employees with 25 or more years of service with the company. Prominent among those in attendance was George R. Carr, chairman of the board.

National Lift Moves

Gar Wood Industries, Inc., will move its National Lift Company subsidiary from Waukesha, Wisconsin, to the company's recently acquired United Stove Company plant in Ypsilanti, Michigan, according to an announcement by E. R. Leeder, Gar Wood executive vice president and United Stove president. Ross Miller, general manager of National Lift, will continue in his present capacity in directing distribution, according to Leeder. Manufacturing operations will be under the direction of Kenneth B. True, recently elected vice president and general manager.

Le Roi Consolidates Offices

Le Roi Company has integrated its plant and industrial engineering departments under the supervision of Wesley A. Schaefer who will be manager of the new department.

Walter V. Sovitzky has been named chief industrial engineer.

Brodie Company Opens Dallas Division Office

The Ralph N. Brodie Company, Inc., has recently moved its Mid-Continent division offices to new enlarged quarters at 167 Parkhouse Street, Dallas, Texas. In addition to modern air conditioned offices, the new location incorporates complete service and stockroom facilities for handling Brodie meters and parts. The Brodie organization at Dallas is headed by J. J. Kropp.

U. S. Rubber Expands

Naugatuck Chemical Division, United States Rubber Company, has announced that it is doubling the production capacity of its Marvinol vinyl resin plant in Painesville, Ohio. The expansion program, which is expected to be completed by June, 1953, will lift production to more than 50,000,000 lb annually.

Training Program Set Up

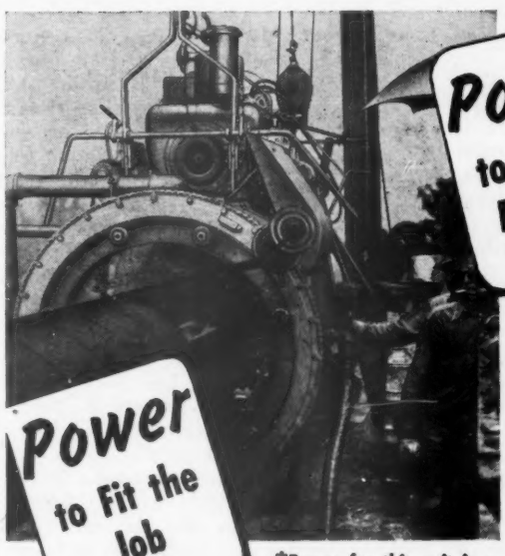
Arthur G. McKee and Company has instituted an extensive training program, under the direction of its personnel department, with John F. Walker as training director. The purpose of the program, which is open to all employees, is to provide the company personnel with an opportunity to learn about all phases of the company's management, engineering, and construction operation.

Hammel-Dahl Agents Named

The Hammel-Dahl Company announces the appointment of James E. Dyer Company of Tulsa and Oklahoma City, Oklahoma, as additional sales and service representatives. James E. Dyer and Leo E. Johns are in the Tulsa office. Joe H. Sallee is in charge of the Oklahoma City office.

J. E. Dyer

WISCONSIN-POWERED Pipe-Coating and Wrapping Machine



*Power for this unit is a model VF4-D V-type 4-cylinder engine developing 25 hp.

A Line Traveling Coating and Wrapping Machine built by Perrault Bros., Tulsa, Oklahoma. And the part played by the Wisconsin Heavy-Duty Air-Cooled Engine is an interesting one.

It propels the machine forward, pumps hot enamel from tar kettle to pipe. It even powers the wrapping head applying the protective felt.

Wisconsin Engines get the nod almost every time from pipe machine builders because of their ability to keep going when going is rough . . . also because of the high horsepower to weight ratio.

Write for information about all models, single-cylinder, 2-cylinder and V-type 4-cylinder units, 3 to 30 hp.

WISCONSIN MOTOR
Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
619 S. MAIN STREET, TULSA, OKLAHOMA
M & M BUILDING, HOUSTON, TEXAS
505 SOUTH MAIN ST., WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS.

TRADE PERSONALS

Louis J. Sarosday has been appointed to the position of vice president, engineering, of the J. B. Beaird Company. Sarosday was formerly with Blaw-Knox Company of Pittsburg, Pennsylvania. There, since 1937, he has been manager of engineering and sales of the company's steel forms department and chief engineer of the construction equipment and machinery department. Sarosday is a graduate of the Royal Institute of Technology of Budapest, Hungary.

L. J. Sarosday

T. J. Delany has been named advertising manager of the Autocar Company, succeeding Robert F. Wood who has retired. Delaney was former public relations director. Wood had been advertising manager for 32 years.

M. R. Brice has been named division manager, industrial control sales of Cutler-Hammer, Inc. Brice will have responsibility for the company's industrial control line. Brice, upon graduating from Carnegie Institute in 1928, joined Cutler-Hammer engineering department. In 1946 Brice became an industry specialist in the headquarters in Milwaukee. He was formerly with the St. Louis office.

M. R. Brice

Dr. Wayne T. Barrett has been named manager of the research department of the research and development division of The Davison Chemical Corporation. Dr. Barrett, who was graduated from Michigan State and the University of Pittsburgh, was formerly with Phillips Petroleum Company and the Mellon Institute, where he was junior fellow in catalytic research.

William R. Hainsworth, Fluor Corporation, has been named to the position of technical advisor to the executive vice president, J. Robert Fluor. Hainsworth was formerly research director and vice president in charge of engineering for Servel, Inc. He is at present serving as chairman of the general utilization committee of the AGA domestic gas research committee, and chairman of the committee on approval requirements for gas refrigerators.

W. R. Hainsworth

J. D. Greensward was named vice president, director of manufacturing, general machinery division, Allis-Chalmers Manufacturing Company. He was recently named director of manufacturing for the division at which time he succeeded Fred Mackey who resigned as vice president in charge of manufacturing. **P. F. Bauer** has been named general manager of the Norwood Works and manager of the firm's apparatus department succeeding Greensward.

Charles E. Talbot has been appointed general production manager, Magnet Cove Barium Corporation, and will be in charge of all plants and mines of the corporation. He will work out of the Houston office. **John Tobler** has been named general superintendent of the mine and mill at Malvern, Arkansas. Talbot joined Magcobar in April of this year as general production manager. He received his degree in chemical engineering from the University of Tennessee. Tobler joined Magcobar in 1948.

John Tobler

C. E. Talbot

Tom M. Short, Hughes Tool Company, has been transferred from Lafayette to Shreveport, Louisiana, as Ark-La-Tex division engineer. Short has been associated with the Hughes Tool since 1938. He received a BS degree in mechanical engineering at the University of Oklahoma.

Tom M. Short

Howard J. Evans has been named chief engineer and **Robert J. Sarraf** chief chemical engineer, Rockwell Manufacturing Company's meter and valve division. Evans received a BS degree and a MS degree from the University of Oklahoma. He was then employed in the geophysical departments of Humble Oil and Standard Oil Company of New Jersey. In 1935 he joined Rockwell as an engineer.

Sarraf is a graduate of the University of Pittsburgh. He later served for more than three years as a chemical engineer on research and development projects at the Mellon Institute of Industrial Research. Following service with the U. S. Army, he returned to Mellon.

R. L. Hockley

C. F. Hockley

R. L. Hockley has been elected president of The Davison Chemical Corporation. Chester F. Hockley, formerly president as well as chairman of the board, continues in the latter post. Thus, R. L. Hockley advances from executive vice president to the prseidency of the corporation, which he helped his father bring to its present position. The elder Hockley, as receiver, assumed direction of the old Davison Chemical Company in 1933 and has continued in charge of the reorganized corporation. R. L. Hockley has moved from engineering to sales, then to general management. He was graduated from Cornell University.

F. P. Murken has been appointed manager, industrial hose division, Quaker Rubber Corporation, division of H. K. Porter Company, Inc. Murken, in his new position, will be in charge of sales for all types of industrial hose manufactured by Quaker. He joined Quaker in 1944.

R. E. Metzger has been appointed manager of tubular sales for The Colorado Fuel and Iron Corporation. Metzger, a Colorado School of Mines graduate engineer, came to CF&I following discharge from war service. In 1952, Metzger was returned to Denver as assistant to vice president Jones.

R. E. Metzger

F. E. Amacker, Jr., Continental Supply Company, is now manager of the Harvey, Louisiana store. The Carthage, Texas, store is now under the management of **R. M. Bynum. J. L. Powell** has been appointed manager of the Liberal, Kansas store. Each of these new store managers were formerly field salesmen at the stores they now manage.

E. D. "Don" Tull has been named to the newly created position of vice president and general manager of Cummins Engine Company, Inc., at Columbus, Indiana. Tull has been with Cummins since 1928. In February of this year he was named vice president of personnel and plant and recently was elected to the company's board of directors. As vice president and general manager he will be responsible for coordinating the work of the five divisions.

E. D. Tull

F. C. "Bud" Hilker, public relations and personnel director of Eastman Oil Well Survey Company, was elected first vice president of the national Society of Associated Industrial Editors at the annual convention of the organization recently held in Carlsbad, New Mexico. Houston has been selected as the 1953 convention city. The industrial editors will be hosts at a joint convention with the International Council of Industrial Editors.

F. C. Hilker

Willis L. Manning, research pioneer in the field of sound control, has been elected president of the National Noise Abatement Council. Manning, who is president of Burgess-Manning Company, was associated for many years with the late Dr. C. F. Burgess in the discovery and development of early sound absorbing materials. Other officers named were **Carl W. Lemmerman,** vice president, and **Wallace Waterfall,** secretary-treasurer. Directors named were **F. P. Hutchinson, George I. Smith,** and **Paul Washburn,** New York.

W. L. Manning

Dwight Richards has been named director of engineering, Oliver United Filters, Inc. Richards brings to his new responsibilities many years of diversified engineering-management experience in the field of heavy process and industrial machinery.

A. O. Putnam has been named public relations director of Layne and Bowler, Inc. He has been advertising manager of the corporation for some time and the new appointment brings all advertising and public relations under his direction. He is a native Texan and has had wide experience in the advertising field, holding responsible executive positions with leading firms in Atlanta, Dallas, Memphis and other southern cities.

A. O. Putnam

Dr. Wilson S. Brubaker has been named senior research physicist and Dr. Paul Brock has been named engineering mathematician, Consolidated Engineering Corporation. A graduate of Miami University and California Institute of Technology, Brubaker will work in the field of mass spectroscopy. He was formerly with Westinghouse Electric Corporation. Brock, a New York University graduate, will work with the company's computer group.

W. L. Childs, Jr., has been named sales manager of the Oil Tools division of Reed Roller Bit Company. Childs, who was graduated from the University of Texas in 1939, has been with Reed Roller Bit since graduation, except for a period between 1941 and 1946 during which he served in the Air Force. Following his release he returned to Reed as sales engineer, becoming Gulf Coast sales manager in 1949.

W. L. Childs, Jr.

W. F. "Bill" Bettis is the successor to **T. M. Johnston** following Johnston Tester's transferring of Tommie Johnston from Los Angeles to Houston as executive vice president and assistant to W. B. Taylor, president. Bettis, a member of the staff of the original M. O. Johnston oil field service since 1933, is now vice president of Johnston Testers, Inc., in charge of the West Coast division and export sales. Bettis began in the oil fields with Wilshire Oil Company at Santa Fe Springs in 1928. He joined Pacific Tool, forerunner of the Lane-Wells Company, as tool designer in 1931.

W. F. Bettis

A.P.I. PIPE COUPLINGS

All Sizes and Types for Oil Field Use

LINE PIPE COUPLINGS A.P.I.
⅛" to 12"—Seamless and Special Processed—Black or Galvanized

PLAIN TUBING COUPLINGS A.P.I.
1" to 3"—Seamless

EXTERNAL UPSET TUBING COUPLINGS A.P.I.
¾" to 3½"—Seamless

CASING COUPLINGS A.P.I.
4½" to 13⅜"—Long or Short

HYDRAULIC COUPLINGS
⅛" to 3"—Seamless

REAMED AND DRIFTED A.I.S.I.
¾" to 12"—Seamless or Spl. Processed

DRIVE PIPE COUPLINGS
⅜" to 12"—Seamless or Spl. Processed

Consult Our Nearest Quick Service Sales Office:

Albany, N. Y.—Albert L. Becker, 434 Clinton Ave.
Baltimore—Ted Barto, 2301 N. Charles St.
Buffalo—W. E. Spencer & Assoc's, 241 S. Elmwood Ave.
Chicago—Harry A. Jay, 122 So. Michigan Ave.
Denver—Earl H. Jones & Co., 1863 Wazee St.
Detroit—Thomas L. Osberger, 19451 Livernois Ave.
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Wm. F. Bennett, 53 Minot St.
Ferguson, Mo.—Wm. H. Heckenberg, 635 N. Florissant Rd.
Houston—Henry H. Paris Distributor, Inc., Box 932
Los Angeles—James A. Riordan Co., 1400 Santa Fe Ave.
Minneapolis—Lin J. Krause, 200 Lumber Exchange
Narbeth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Murray Eskin, Industrial Office Bldg.
New York—Henry Stein, 50 Cliff St.
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., Mutual Bldg.
San Francisco—Earl H. Jones & Co., 1150 Folsom St.
Seattle—Earl H. Jones & Co., 819 Thomas St.

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WHEELING MACHINE PRODUCTS COMPANY

ELM GROVE STATION — WHEELING, W. VA.

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Ounces Only Once A Week give a new operating efficiency and economy. Don't Be Satisfied With Less
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AMERICAN SAND BANUM CO
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Trade Personals

Vernon Mandt has been appointed sales manager of the Bushwacker division of the American Steel Dredge Company, Inc. Mandt was formerly sales manager of the Mandt manufacturing division of Pettibone-Mulliken Corporation, and founder of the Mandt Manufacturing Company. Prior to that he served Jaeger Machine Company for 15 years.

V. Mandt

Dr. E. C. Bain, vice president—research and technology of United States Steel Company, recently was awarded the highest honor given by the leading metallurgical society of France, La Societe Francaise de Metallurgie. Dr. Bain, the first American to receive the Grand Medal, which has been awarded only six times previously, was honored at the closing session of the society's fall conference in Paris for his contributions to metallurgical research.

A. O. Williams has been named director of engineering, industrial truck division, Clark Equipment Company. He will coordinate and lead all Clark engineering activities in the field of material handling equipment. Williams was graduated from the University of Michigan in 1914. He began his career with Clark in 1917.

John Howard Wood has been appointed store manager of the United Supply and Manufacturing Company store in Pauls Valley, Oklahoma. Wood has been affiliated with United Supply since 1950. The United Supply Pauls Valley store is an important link in their 27-store network.

John H. Wood

C. K. Stillwagon, president of Keystone Tool Corporation of Houston, Texas, has returned from an extensive visit through the Rocky Mountain and West Coast states, during the course of which he arranged for many additional sales outlets for his company.

R. J. Eiche and Associates, with headquarters in Los Angeles, California, were appointed as Keystone representatives in several Eastern states. Stillwagon also announced that Hamer Oil Tool Company, Keystone representative on the West Coast.

Harry C. Crumley has been promoted to the position of division credit manager of The National Supply Company in its Northwest division. The division covers Wyoming, Montana, Utah, Colorado, North Dakota, South Dakota, Western Nebraska, and Northwestern New Mexico. Crumley has served at the division headquarters, Casper, Wyoming, since January, 1951.

Dr. John McGavack has been appointed technical director of the plantation division of United States Rubber Company. Dr. McGavack succeeds **Dr. E. M. McColm** who is transferring to research and development work at the general laboratories in Passaic, New Jersey. In his new position, Dr. McGavack will direct the plantation's research and development work.

Joe Rucker has been transferred to the sales department of Stewart and Stevenson Services Odessa, Texas, branch. Rucker will specialize in oilfield engines and irrigation equipment. Formerly a member of the service department, Rucker has been with Stewart and Stevenson since the opening of the Odessa branch early in 1952.

Tom Seago, employed by the Acme Oil Tool Company of Oklahoma City since 1943 as a fishing tool operator, has recently been promoted to fishing tool superintendent. Seago's experience in rotary and cable drilling dates back 25 years. Previous to his employment with Acme, he worked as a roughneck, driller, toolpusher, and drilling contractor.

Tom Seago

W. M. Boren, chief engineer for Rolo Manufacturing Company, is making an extended tour of the Alberta and Williston Basin oil operations. He plans to inspect the operation of Rolo oil and gas metering systems and equipment under severe winter conditions, and continue the research program on the completely housed metering units in development by Rolo for sub-zero operations.

George Klein has been appointed as district manager, at Nashville, Tennessee, and **Bernard C. Manker** as district manager at Lansing, Michigan, of The Davison Chemical Corporation's mixed fertilizer division. Klein, formerly manager of the Nashville plant, is now in charge of a group of plants serving the south and areas west of the Mississippi River. Manker, formerly manager of the Lansing plant, takes charge of a group of plants serving the midwest, principally Michigan, Ohio and northern Indiana.

Joseph Maxwell Welsh has been transferred to the Dallas district sales office from the Tulsa headquarters of The Bovaird Supply Company. Having specialized in wire rope sales with American Steel and Wire Company in the Southwest, Welsh has had some 20 years' experience in sales in the Texas and New Mexico territory.

Charles F. Hauck has been promoted to assistant sales manager of the Chemical Plants Division of Blaw-Knox Construction Company. In addition he will continue his duties as the division's manager of sales promotion. In his new capacity Hauck will coordinate the sales efforts of the branch offices.

E. W. Petersen

F. E. Swain

E. W. Petersen has been named general sales manager, American Blower Corporation. Petersen joined the company in 1923. He became merchandise manager for the packaged products of the corporation's heating and ventilating divisions in 1932, and was elevated to assistant general sales manager in 1951. His new duties will cover all divisions of the corporation.

F. E. Swain has been named assistant general manager, Jarecki International Supply Division, H. K. Porter Company, Inc. He will assist the general manager in all operations of Jarecki International. During his more than 10 years experience in the oil field supply business he has served in various capacities with IDECO at Columbus and in the IDECO Supply Store Division.

Ira C. Wells has been named Rocky Mountain area representative for The McEvoy Company. Wells will make his headquarters at Williston, North Dakota in the heart of the Williston Basin. Although he has just recently joined the McEvoy Company, he is no newcomer in his present field as he has spent the better part of his life in the oil field supply business. During these years he has covered the Mid-Continent, West Texas, and the Gulf Coast — more recently covering the Rocky Mountain Area.

J. C. Wells

John C. Weaver has been appointed district credit manager of The National Supply Company at Olney, Illinois. His district includes southern Illinois, southern Indiana, and western Kentucky. Last month Weaver completed his second tour of duty with the Army. Prior to his recall to service in 1951, he was senior credit clerk of the division credit office at Fort Worth. Previously he was in the district office in Houston.

H. F. Detrick, vice president of A. O. Smith Corporation of Milwaukee, assumed additional responsibilities in the corporation's management recently and transferred his operating headquarters from Los Angeles to Milwaukee. In his new assignment Detrick has direct jurisdiction over A. O. Smith's capital goods manufacturing and marketing business. Until October 1 he had been vice president and general manager of the Pacific Coast division.

Richard H. Koehler has been appointed manager of Le Roi Company's advertising and sales promotion department, replacing **Guy Scrivner** who has been transferred to a position in Le Roi's engine sales department. Koehler has been advertising manager of Stearns Magnetic, Inc., since 1948. Scrivner has been advertising and sales promotion manager of Le Roi Company since 1948 and prior to that he had extensive experience in consumer goods advertising.

William J. Bucklee has been named general sales manager of the Johns-Manville Celite Division, Johns-Manville Corporation. Bucklee succeeds **William D. Van Arnam** who has retired. Bucklee joined Johns-Manville as a sales representative when the Celite Products Corporation was acquired by Johns-Manville in 1928. He graduated from Kansas State College.

E. J. Lyons

Emerson J. Lyons has been named as general manager for General American Transportation Corporation's Turbo-Mixer Division. Lyons, who succeeds James E. Moul, retired, has offices at 10 East 49th Street, New York City.

Carleton B. Edwards, president, Reilly Tar and Chemical Corporation, recently received a citation in the field of business from Earlham Colege, Richmond, Indiana. The citation was one of 20 bestowed on outstanding Earlham alumni for their notable records in their professions and for public service that has reflected honor on their college. He was graduated from Earlham in 1915 and is secretary of the Earlham Foundation. Edwards, before joining Reilly Tar & Chemical Corporation, served as head of the chemistry department of Guilford College.

F. E. Suder has been named general manager of Jarecki International Supply Division, H. K. Porter Company. Suder, until now sales manager of the division, will be in complete charge of all operations of Jarecki International. His experience covers more than 35 years in various phases of the oil and gas industry.

F. E. Suder

Canute R. Olsen has been appointed manager of the market development division and **Linus E. Olson,** manager of the inventory control division in the sales department of United States Steel Supply Division. Olsen, a 1941 graduate of Illinois Institute of Technology, succeeds **Leslie G. Hulbert,** who is transferred to the Chicago district in charge of machinery and specialty sales. Olsen joined U. S. Steel as a clerk in 1936.

William Wight has been named as director of public relations of Philco Corporation. Wight, Washington vice president of Carl Byoir and Associates, has been in charge of the nationwide public relations firm's Capital activities for the past 14 years.

Carl White, Jr., president of Franks Manufacturing Corporation, of Tulsa and Mrs. White, sailed from New York recently for a three months trip to the British Isles and Europe during which White will seek to work out arrangements for Franks to obtain more business from foreign sources. The trip will take him to England, France, Belgium, Holland, Germany, and Italy.

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WASH PIPE!
to wash over
7½" - 8" O.D. collars in 9" hole
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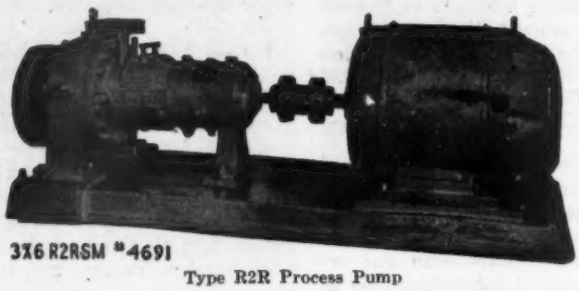
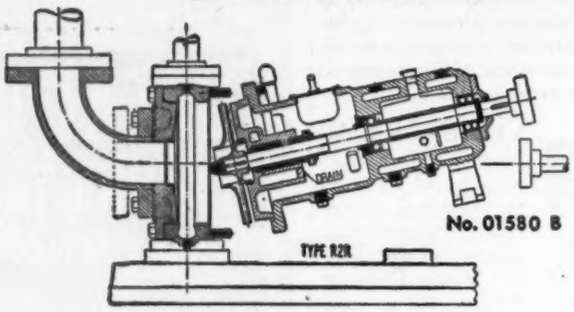
Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

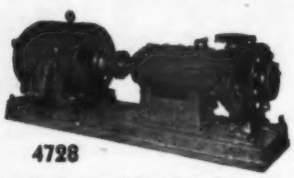
CENTRIFUGAL AND RECIPROCATING PUMPS

Close Coupled Centrifugal Pump

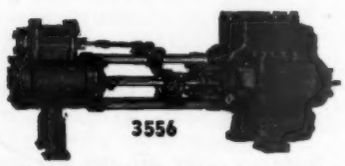
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

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Branch Offices: NEW YORK, N. Y., HOUSTON, TEXAS

Representatives in Principal Cities

Reid Grainger, left, receives 30-year pin from F. C. Merritt, vice president, Byron Jackson Company.

Reid Grainger was honored at a luncheon recently to commemorate his thirtieth year with the Byron Jackson Company. Reid joined the Elliott Core Drilling Company (later purchased by BJ) in 1922. Many of the old Elliott gang were present and the event was climaxed by the presentation to Reid of his 30-year pin by F. C. Merritt, executive vice president.

John S. Conway, who was general sales manager, Koehring Company of Milwaukee, has been named vice president in charge of sales and **John E. Chadwick,** with the company since 1945, was named sales manager. In his new post, Conway will fill the vacancy created earlier this year when J. R. Steelman became president of Koehring. Chadwick will return to the Koehring Company after serving for a year as western sales manager at the Kwix-Mix Company, a Koehring subsidiary. Previously he had been assistant sales manager for Koehring. Conway joined Koehring in 1941.

John E. Chadwick

John S. Conway

J. F. Austin has been appointed manager of Standard Equipment Sales and also regional sales manager of Engine Life Products Corporation. He will have his headquarter at Dallas and will be in charge of Midwest territory including the Great Lakes region. Austin was formerly associated with De Luxe Products Corporation of La Porte, Indiana.

J. F. Austin

▸ **Karl E. Johnson,** who for the past six and one-half years has represented J. F. Pritchard and Company as Chicago district sales manager, has been named to

K. E. Johnson

R. C. Kelly

succeed **Raymond C. Kelly** as manager of Pritchard's equipment division in Kansas City. Succeeding Johnson in Chicago will be **E. Allen Bailey.** Kelly resigned to accept the position of executive manager of the Cooling Tower Institute, an association of major manufacturers of industrial water cooling equipment.

▸ **R. L. Lloyd** has been appointed general manager of advertising and **R. A. Wheeler** assistant general manager of advertising of The International Nickel Company, Inc. In consolidating into one department the advertising sections of the Nickel Sales and Inco Nickel Alloys Departments under Lloyd and Wheeler, the following other appointments were made: **M. J. Phillips,** assistant to the general manager of advertising and **H. S. Lewis** and **A. P. More** assistant managers of advertising.

▸ **Jack Davis** has been appointed to the Jackson, Mississippi, sales office it has been announced by The Trane Company, La Crosse, Wisconsin. Davis has a degree in mechanical engineering from Mississippi State College at Starkville. He is a graduate of the Trane Student Training Program of 1952.

▸ **Malcolm Smith** has been added to the board of directors of Byron Jackson Company, increasing the number of board directors from eight to nine. Smith, a graduate of Brown University and Harvard Business School, has maintained his office in Los Angeles since 1948. He was formerly a partner of J. H. Whitney and Company.

▸ **H. M. Kelly** has been appointed special regional representative of the Hughes Tool Company in Tulsa, Oklahoma. Prior to his move to Tulsa he was special sales representative in Hughes' general sales department in Houston, Texas. Kelly replaces **J. S. George** who resigned to become vice president and general manager of the B and R division of the Trans Era Oils, Ltd., in Wichita, Kansas.

H. M. Kelly

Kelly began his association with Hughes in Midland, Texas, in 1937 as a field salesman.

▸ **Joe Webster,** Magnet Cove Barium Corporation, has been appointed assistant general sales manager. His headquarters will be at 123 Oil and Gas

Joe Webster

Ray Dillman

Building in Houston, Texas. Webster joined Magcobar in 1947, and has been division manager of the Texas Gulf Coast Division since 1951.

Ray Dillman has been appointed to succeed Webster as manager of the Texas Gulf Coast Division. He attended Oklahoma University and received his B.S. degree from Oklahoma Central State College. Dillman joined Magcobar in March, 1948.

Ernest Howell has been appointed supervisor of District 3. A graduate of Rice Institute, he joined Magcobar in January, 1950.

Jack Walker has been named export salesman. Since joining Magcobar in 1949 he has been district supervisor at Victoria and has served in New Orleans, Louisiana, Farmington, New Mexico, and in Canada.

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If you are moving or expect possibly to move any time soon, save the coupon below for your convenient change of address. It will prevent your copy of The Petroleum Engineer from being lost or misdirected.

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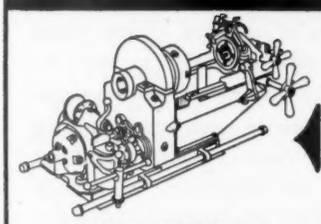
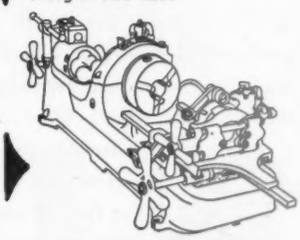
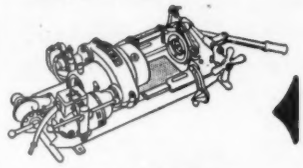


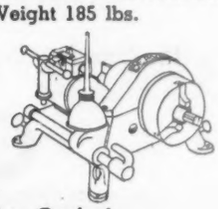
BEAVER MODEL-A
A rugged, Heavy-Duty Machine. Range ⅛ to 2". Up to 12" with Geared Tools and Drive Shaft. Bolts ¼ to 2"—Weight 365 lbs.



BEAVER MODEL-B
A Middleweight Utility Machine. Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 235 lbs.



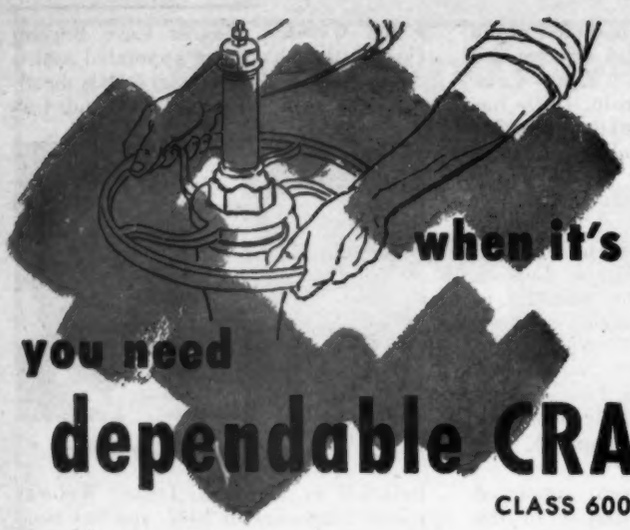
BEAVER MODEL-E
A Lightweight Portable Machine. Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 185 lbs.



BEAVER MODEL-C!
A sturdy little Power Drive that converts Hand Tools into Power Tools—Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 140 lbs.

Write for NEW Complete Catalog!

BEAVER PIPE TOOLS, 256-300 DANA AVE., WARREN, OHIO



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you need dependable CRANE pipe line valves

CLASS 600 GATES

they give you
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- COMPLETE GREASE SEALING
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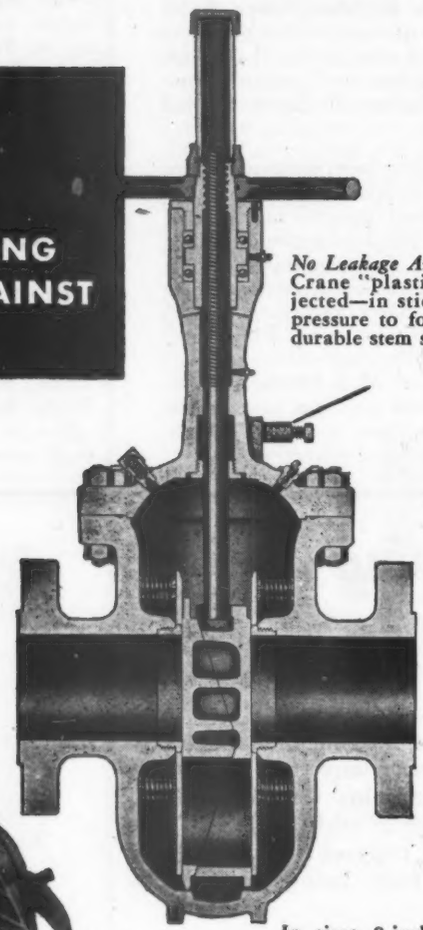

No Leakage Around Stem with Crane "plasti-packing." Injected—in stick form—under pressure to form a tight and durable stem seal.

Infrequent operation—long exposure in toughest weather—can't affect the efficiency of Crane Pipe Line Gate Valves. All working parts are sealed in grease to assure smooth operation and positive closure of the dual-seating double disc. Spring-loaded plates retain grease in body during operation. There's no problem of erosion either, since disc is fully seated in open position as well as in closed position. Equally important, see how the conduit-type disc ports coincide with seat opening—note the absence of dirt-catching pockets. That means smooth flow with no turbulence, minimum pressure drop—and absolute minimum of internal wear from normal service.

Full-Way or Venturi patterns for working pressures up to 1440 pounds, oil or gas. Sizes 2 to 30-inch, Flanged or Butt-Welding ends. Full information contained in Circular AD-1864. Ask your Crane Representative, or write direct.

In sizes 8-inch and larger, a *new Spring Counterbalance Unit* keeps both sections of the wedge disc in alignment for quicker response—easier operation.

Spring-loaded plates retain grease in body while valve is being operated. In addition, they wipe foreign matter and excess grease from disc faces and help guide the disc.

The Complete Crane Line Meets All Your Valve Needs. That's Why

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BOOKS

Weldability of Metals, *reprinted from the ninth edition of Procedure Handbook of Arc Welding Design and Practice. Published by Lincoln Electric Company, Cleveland 17, Ohio. Price, $.50. Pages, 195.*

These data are a direct reprint from Chapter 2 of the "Procedure Handbook of Arc Welding Design and Practice," and the weldability refers to arc welding processes only. Characteristics affecting weldability, tests, choice of steels for best weldability, and A.E.S. specifications are given. Then headings are divided specifically into methods of welding specific metals, such as clad steels, forgings, cast steel, cast iron, wrought iron, ingot iron, galvanized steel, enameling stock, and terne plate. There is also a heading one arc weld surfacing—hard facing.

Maleic Anhydride Derivatives, Reactions of the Double Bond, *by Lawrence H. Flett and William Howlett Gardner, Published by John Wiley and Sons, 440 4th Ave., New York 16, N. Y. Pages, 251.*

This book is intended for students and research workers interested in synthetic organic chemistry, and for industrial chemists confronted with the problem of finding suitable chemicals to solve specific problems. Selected types of reactions are graphically portrayed on the right-hand pages. Only the reactants and end products are shown. Any attempt to portray the reaction mechanism has been avoided. Preparations of the products are described briefly, and a series of references is given to assist further study.

The Oil and Gas Directory, *published at 504 Richmond, Houston 6, Texas. Price, $22.50. Pages, 608.*

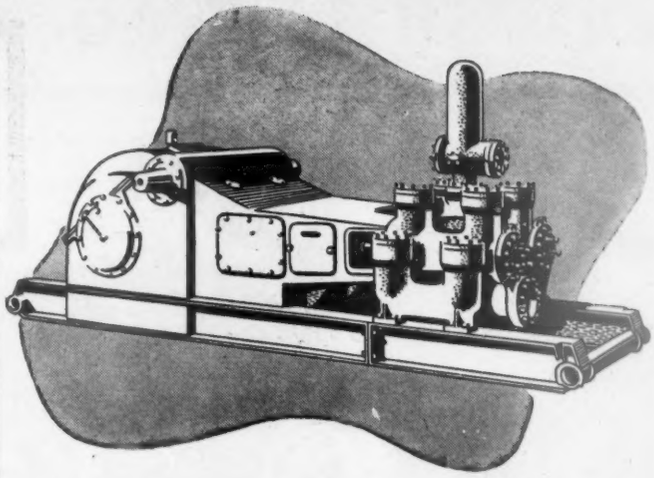
The 1952-53 edition of the Oil and Gas Directory contains a much expanded listing of individuals, companies, and addresses of all personnel and businesses in the oil and gas industries in the Southwest (Texas, Oklahoma, Louisiana, and New Mexico). A complete index of all oil companies, drilling companies, producers, marketers, and oil well servicing companies is given. Individuals are listed in alphabetical order at the beginning of the book, giving the name, initial, and page number. A new feature lists the individuals under company names, by title. The directory is cross indexed, and gives the names, telephones, and addresses.

Tulsa Geological Digest, *published by Tulsa Geological Society. Copies available from R. E. Megill, Carter Oil Company, Box 801, Tulsa, Oklahoma. Price, $2. Pages, 281.*

More than 25 geological articles appear in this new Vol. 20 of the Digest. Among them are: "Stratigraphy of Oklahoma" by Robert H. Dott; "Geological Fact Finding vs. Prejudice," by Frank A. Morgan; "Air Photos in Geology," by H. T. U. Smith; "Geophysical History of the Golden Trend," by John R. Hill; "Stratigraphic Possibilities of the Dakota Side of the Williston Basin," by John Paul Gries, and many others. Several pool papers, three articles on electrical logging, and several articles on stratigraphy appear in the book. There are three geologic reports on Oklahoma, with maps and cross sections. A listing of the members of the Tulsa Geological Society also is given in the back of the book.

The Copyright Law, *by Herbert A. Howell. Published by The Bureau of National Affairs, 1231 24th Street, N. W., Washington 7, D. C. Price, $7.35. Pages, 355.*

This Third Edition, completely revised, gives an analysis of the law of the United States governing registration and protection of copyright works, including prints and labels. The book is from a series of lectures on copyright originally delivered to graduate law students. Sections deal with the subject matter of copyright, commercial prints and labels, non-copyrightable material; statutory requisites; deposit of copies and registration of works first published; ad interim copyright; renewal of copyright, and others. Separate chapters take in copyright relations with other countries, and copyright in territorial possessions of the United States.



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Slush pumps consume the main power of a rig, and American Blower Gýrol Fluid Drives save power on the slush pump by extending the pumping range.

Here's how: During normal operation Gýrol Fluid Drive efficiently smooths out the power flow from engine to pump. As the pressure increases with depth and the engine becomes fully loaded, the slip feature of Fluid Drive allows the pump to slow down while the engine operates in its most efficient range. Fluid Drive permits continued output of full engine torque while the volume output of the pumps is gradually reduced to a predetermined minimum.

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for real EMULSION-BREAKING ACTION!

ONE drum of the right Visco formula for your oil will get you the real emulsion-breaker action that makes permanent Visco customers. DRY oil, *fast*, at a treating cost per barrel that will be a pleasant surprise, is what you can expect—and get—with Visco. Call Houston, Capitol 7300, collect, for service as fast and efficient as Visco Chemicals.

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INCORPORATED
City National Bank Building
Houston 1, Texas

Visco®... CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS

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New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) STORAGE TANK

Murdock Tank and Manufacturing Company of 3418 South Santa Fe Street, Tulsa, Oklahoma, is manufacturing a new glass reinforced plastic bolted lease storage tank. It is designed to eliminate corrosion, electrolysis, and paint problems. The reinforced plastic has great impact resistance and dimensional stability. Temperature extremes are no longer a problem. Various sizes are available.

Circle letter (A) on reply card.

(B) ALARM SYSTEM

The Potter "Max-Alarm" system is designed as a safety or warning device for processes or equipment where the flow through a pipe line is not to exceed a given value. With a built-in relay having a capacity of 8 amp at 125 v, it can be used to operate a visual or audible warning signal and also to shut off a pump or close a motorized valve when the maximum limit is exceeded.

Circle letter (B) on reply card.

(C) CHAIN FAILURE

A giant step in the direction of solving the old problem or rig down-time due to premature chain failure and replacement has been announced by Chain Belt Company of Milwaukee. An easy-to-assemble riveted roller chain does the trick. Called the improved Baldwin assembly riveted oil field roller chain, it is being produced by the Baldwin-Duckworth division of Chain Belt Company.

Circle letter (C) on reply card.

(D) PRESSURE VALVE

The new "Wee Willie" high pressure, low flow control valve was recently introduced by the Annin Company. This valve is pneumatically controlled, and is specifically adapted to pilot plant operation. Standard models are available with working pressure ranges of 10,000 psi and 30,000 psi, with special assemblies up to 50,000 psi.

Circle letter (D) on reply card.

(E) METERING PUMPS

For those who require the utmost accuracy and dependability in the metering of small volumes of liquid, the new line of Maisch metering pumps offers unusual advantages. The line embraces many different capacities ranging from zero to 3.6 gal per minute. The design of the Maisch pump permits metering with accurate control volume.

Circle letter (E) on reply card.

(F) CHEMICAL INJECTION

A new air or gas powered pump designed for high pressure chemical injection in refineries, oil fields, and chemical plants, and for low pressure oil well slugging, has recently been introduced on the market by the sales division of McFarland Engineering and Pump Company.

Designed with 3/16-in. plungers, this pump will pump from one-half pint to 50 gal per day.

Circle letter (F) on reply card.

(G) SPIRAXIAL COMPRESSOR

A gas or air compressor called the "Spiraxial Compressor," entirely new in principle and design within its range, was displayed for the first time by Roots-Connersville blower at the 1952 convention of the American Gas Association. Instead of conventional rotors, the Spiraxial compressor employs two intermeshing screw-rotors that rotate in opposite directions.

Circle letter (G) on reply card.

(H) RECORDING GRAVITOMETER

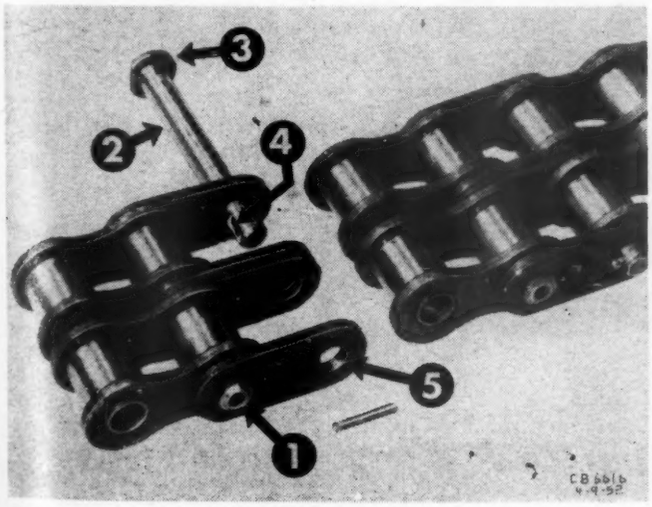
Refinery Supply Company has announced the new RS liquid recording gravitometer. The new machine, is the latest development in liquid gravity measurement. The new invention is used for indicating and recording the specific gravity or density of liquids and especially flowing liquids that may be subjected to high pressures and to changes in temperatures.

Circle letter (H) on reply card.

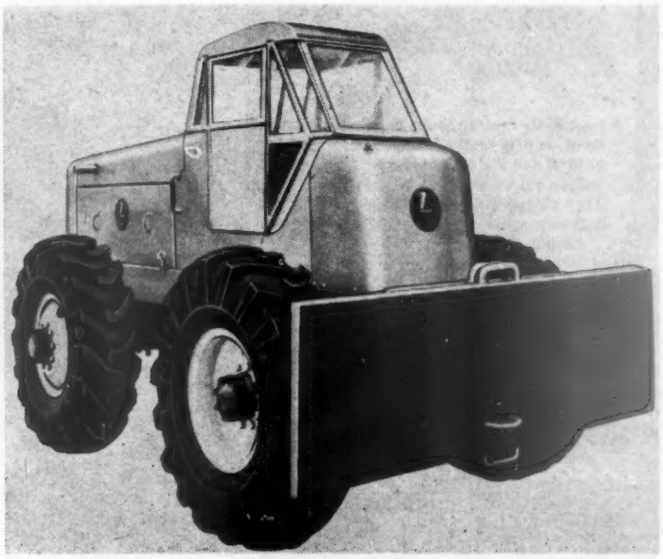
(I) TRACTOR

The Frank G. Hough Company announces a large rubber-tired tractor, having four wheel drive and other important advantages. Known as the Model TM "PAYLOADER" tractor, it is available with a 106 hp gasoline engine or a 90 hp diesel engine, weighs 25,000 lb and develops up to 16,000 lb and 14,000 lb drawbar pull.

Circle letter (I) on reply card.



Chain Belt Company's riveted roller chain.



Large rubber-tired tractor developed by Frank G. Hough.

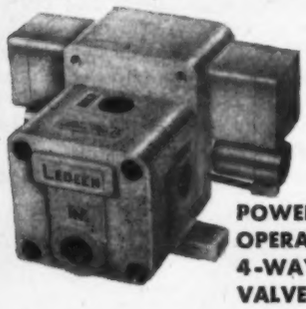
GET THE MOST OUT OF YOUR CYLINDERS with Ledeen VALVES

HAND OPERATED 4-WAY VALVE

Three models: Completely Manual—Spring Return to Neutral—Spring Return to Reverse. Flow cycles to handle most requirements.

FOOT OPERATED 4-WAY VALVE

Same as Hand Operated Valve, except foot operation replaces hand. Leaves hands free for other work.



POWER OPERATED 4-WAY VALVE

For remote control, safety or automatic equipment. Suitable for solenoid, cam, finger, toe or hand operation.

Ledeen valves are built in sizes from ⅛" to 1¼" standard pipe tap—to operate air and hydraulic cylinders and motors, single and double acting.

Write for Bulletin 1000

VALVES • CYLINDERS
AIR-HYDRAULIC PUMPS & BOOSTERS
VALVE ACTUATORS • AIR HOISTS

Ledeen Mfg. Co.
1608 San Pedro
Los Angeles 15, Calif.

Crutcher-Rolfs-Cummings new pipe bending machine.

(J) PIPE BENDING

Crutcher-Rolfs-Cummings, Inc., in cooperation with Transcontinental Gas Pipe Line Company, has completed the first 36-in. smooth pipe bending machine ever built. The machine is portable, track mounted, and weighs 33,000 lb. The over-all length is 24 ft 6 in and width is 92 in. In recently completed tests, the makers claim the new machine smooth bent cold pipe one-half degree per foot. The test pipe had a wall thickness of 0.393 in. and a nominal yield strength of 52,000 psi (test specimen had a yield strength of 58,400 psi).

Circle letter (J) on reply card.

(K) INJECTOR PUMP

A new chemical injector pump, the Mac-4 has recently been put on the market by the sales division of McFarland Engineering and Pump Company. This pump is designed for pumping chemicals in refineries, the oil industry, chemical plants, etc. Powered by a 4-cylinder rotary type crankshaft motor, it is engineered to pump continuous and uniform volume of chemical or lubricant. Built-in oil pump floods all parts of the motor.

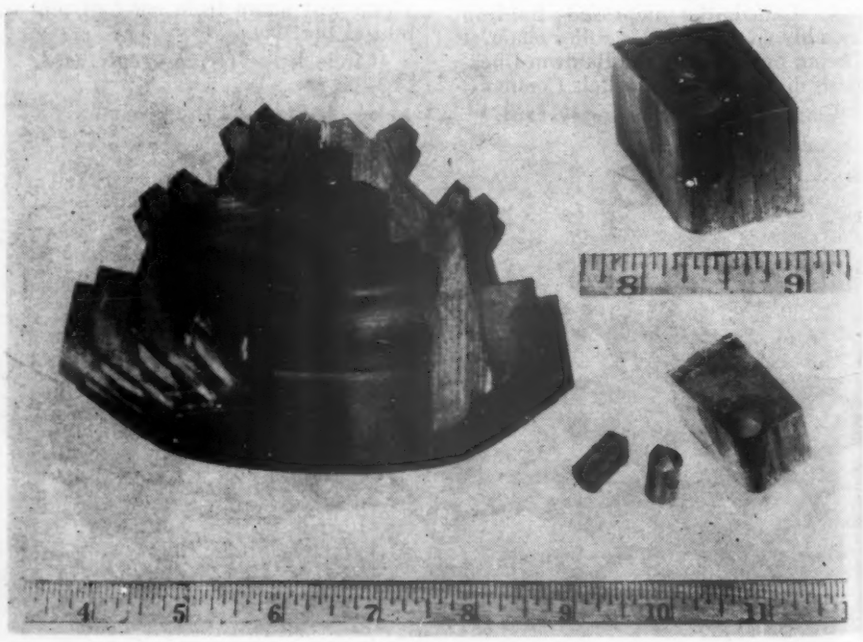
Circle letter (K) on reply card.

(L) CARBIDE PLUGS

A development that is beginning to show effect when drilling cherts, dolomites, bromides, and some igneous rock is the use of Kennametal, Inc., tungsten-carbide inserts as cutter teeth in cone bits. Although not new, the development of this application is only now beginning to demonstrate advantages in the drilling of hard materials and the drilling of formations below 10,000 ft. The advantages include penetration rates of 3 or 4 to 1 over the hardest steel cone bits. An increase in bit life of from three to 10 times over conventional bits is obtained together with the surprising characteristic of increased rates of penetration in the harder formations. Due to its ability to retain gage, rigs can be operated with lower drill collar load and enables straighter and more uniform diameter holes to be drilled.

Inserts for cone bits are of two types. One is a digging plug and the other is a combination ream gage and digging plug. The original and popular process of securing them in the cone body is by mechanical pressure insertion methods. The number of carbide plug inserts in the cone bit are the same as with steel, and the same digging pattern is retained.

Circle letter (L) on reply card.

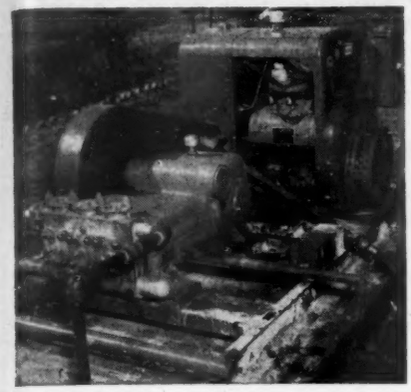


Kennametal carbide plugs recently developed.

New Equipment

(M) OIL PUMP

A new oil pump designed to handle such oil field problems as high pressure transportation of crude oil, salt-water disposal, and pilot floods has been announced by the Harley Sales Company.



The Wisconsin-powered pump is made in 2 sizes, 30 and 50 bbl per hour at 1000 psi, discharge pressure, with various accessories available. Both are fitted with stellite exhaust valves and seats, low oil cutoff switches, and lubricating oil filters especially designed for their low-pressure lubricating system.

Circle letter (M) on reply card.

(N) FUSE DE-ENERGIZER

The Electric Machinery Manufacturing Company has developed a new gang-operated disconnect method for de-energizing the fuses on high voltage motor control and for making them safe and convenient for handling. The new high voltage fuse compartment, which has the trade name "SA-Fuse," uses a movable panel on which current-limiting fuses are gang-mounted. The fuse panel has disconnecting blades behind the panel.

Circle letter (N) on reply card.

(O) ACQUAMETER

Beckman Instruments, Inc., has developed a new Acquameter utilizing the Karl Fischer method for determining moisture content in such products as paper, petroleum products, etc. Some features of the new Acquameter include: A curved ceramic tray protecting the front and side panels from accidentally spilled chemicals, a built-in variable speed matnetic stirrer, an increase in reagent reservoir capacity from 1 to 2 liters, and a great improvement in appearance and compactness.

Circle letter (O) on reply card.

(P) CHEMICAL FEEDER

A new compactly-designed "packaged" chemical feed system is now available from the Milton Roy Company. The package unitizes the basic elements of a chemical feed system, reducing field piping. The unit consists of a 50-to-500-gal carbon steel chemical solution tank mounted over a Milton Roy controlled volume pump. Piping is supplied for the suction line, complete with valves and sight gage for reading liquid level.

Circle letter (P) on reply card.

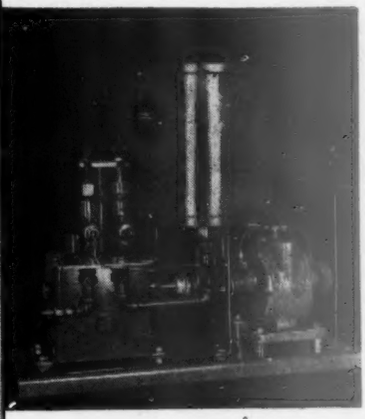
TROUBLE-FREE

GAS DRIVE CHEMICAL FEEDERS

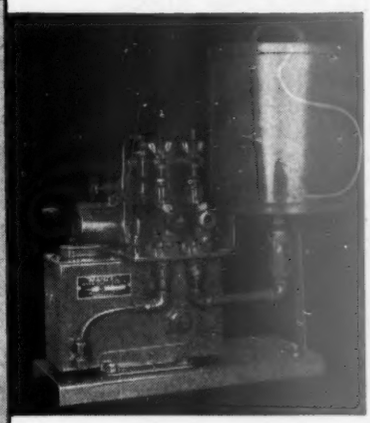
COMPLETELY protected against dirt, corrosion, and the elements, Manzel Chemical Feeders can be depended on to function faithfully 24 hours a day, year after year, with a minimum of attention.

Automatic Force-Feed Lubrication is now available on these feeders when desired. In wet gas fields corrosion often causes stoppage. The lubrication feature retards corrosion, insures constant operation. If gas flow is intermittent the motor will start itself whenever flow resumes.

Manzel Chemical Feeders are available through your local supplier.



ROTARY GAS DRIVE



RECIPROCATING GAS DRIVE

Manzel

291 BABCOCK ST., BUFFALO 10, N. Y.

New Equipment

(Q) PIPE SYSTEM

Durant Insulated Pipe Company has been granted basic patents on a new type of insulated anchor for use in underground insulated pipe systems conveying hot or cold liquids or gases. The anchor is so constructed that contact is eliminated between anchor plate and pipe. The plate is insulated from the pipe line both thermally and electrically by a non-compressible block of Transite sheet material. The design and material serve to minimize heat loss at anchorage points.

Circle letter (Q) on reply card.

(R) VOLTAGE TESTS

A new d-c high voltage dielectric strength testing instrument, Model 424 HYPOT has been announced. The instrument has a continuously variable voltage output and a means to measure output current. Designed for electric insulation tests requiring various potential stresses. Permits calculation of d-c resistance based on test voltage and output current flow. Ammeter protected against damage by output short circuit. A-c ripple within 1 per cent. Special models can be provided with ranges up to 7500 volts.

Circle letter (R) on reply card.

(S) PACKING RINGS

"V" packing rings moulded from pure Teflon are now available in all sizes, from Flexrock Company. One is for low pressure and the other for high pressure, up to 5000 psi. Both types can be used against substance (only molten sodium and flourine at elevated pressure chemically change Teflon) within the temperature range of minus 90 F to plus 500 F.

Circle letter (S) on reply card.

(T) CARRIER SYSTEM

Up to 24 broad-band voice channels can be transmitted over a wide-band radio channel with the new Lenkurt Electric Company Type 33C carrier telephone system. Designed specifically for application to radio links, this frequency division multiplex system is comprised of three eight channel groups. A single group or less can be installed initially and expanded to the maximum capacity in the future as traffic increases.

Circle letter (T) on reply card.

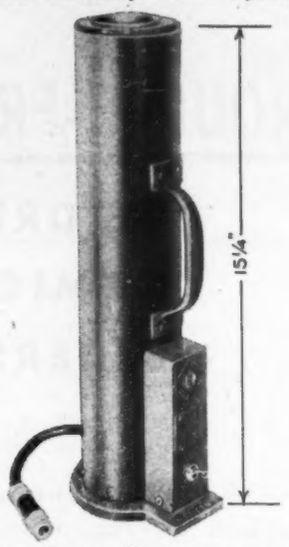
(U) ELECTRIC PLANT

A new ultra-modern and electric generating plant, engineered primarily for emergency stand-by service, is announced by the Universal Motor Company. This new model has a 10 kw capacity suiting it for a wide range of applications, hospitals, theaters, commercial buildings, industrial plants, construction projects, estates, etc. It is available with electric starting or can be supplied wih controls that automatically start the plant the instant regular power fails. One of the important features of this model is its four cylinder air cooled gasoline engine.

Circle letter (U) on reply card.

(V) HYDROMETER CYLINDER

L-K Pump Valve Comany has announced its new Melton heating hydrometer cylinder which is designed and built to meet the growing need of the petroleum industry for a hydrometer



cylinder that will heat samples of waxy crudes so that hydrometers will float in these samples, thus assuring correct readings. The heat is thermostatically controlled and the thermostat can be set to the desired temperature according to conditions encountered.

Circle letter (V) on reply card.

(W) BUBBLE CAPS

Bubble caps of high strength cermic are now being manufactured by Coors Porcelain Company, for general use in fractionating and distillation towers where severe corrosion limits the useful service life of metal caps. Coors bubble caps can now be made of any of several special ceramic materials, depending upon the service conditions and the shape or design of the cap. Also the high tensile properties and hardness of Coors ceramic materials make it resistant to mechanical damage.

Circle letter (W) on reply card.

(X) FLUORESCENT INSPECTION

A new Blak-Ray ultra-violet source designed specifically for industrial fluorescent inspection, processing, and packing operations, is announced by Ultra-Violet Products, Inc. The principle of fluorescent inspection is based on the fact that many substances, when activated by ultra-violet energy, emit a visible glow called fluorescence.

Circle letter (X) on reply card.

(Y) TEMPERATURE HUMIDITY

A new development in control makes it possible to hold humidity within one degree wet bulb in Aire regulator temperature and humidity cabinets, Food Technology, Inc., reports. Temperature is controlled by thermostats that turn heaters or open valves admitting a coolant. Humidity is controlled by a wet bulb device that atomizes water into a separate chamber through which the air is circulated.

Circle letter (Y) on reply card.

(Z) LIQUID-PLASTIC COATING

A newly-developed, liquid-plastic coating that dried quickly to a smooth satin finish resistant to moisture, abrasion, fire, and corrosion is being used here for the first time to make better blades for industrial cooling-tower fans. Known as Aeroloid, the plastic coating was developed jointly by the Metal Products Division of Koppers Company, Inc., and the Tennessee Eastman Company. Following stringent tests, it has been adopted for use on all sizes of Aeromaster industrial fans made by Koppers, which range from 4 ft to 20 ft in diameter.

Circle letter (Z) on reply card.

(AA) FORMATION PACKER

The Guiberson Corporation has announced its new PE formation packers for open hole control. These packers have been used with great success, the company reports, in the Rangely field of Colorado. Wells in this field have several hundred feet of 6⅛-in. open hole, diamond drilled very hard formation. In most of the wells, a large volume of gas is produced at the top of the producing zones. Where this occurs and the gas/oil ratio is too high, PE packers are used to seal off the high volume gas production zone from the oil-producing formation. PE packers have a long lid cup type automatic seal.

Circle letter (AA) on reply card.

(AB) PRESSURE TRANSDUCER

Pressure measurements ranging from theoretical investigations of aircraft turbulence-distribution patterns to practical surveys of hydraulic-system and pipe line pulsations are simplified by a miniature pressure transducer announced by Consolidated Engineering Corporation. One of the smallest instruments of its type ever designed for quantity production, the new Type 4-310 "Star" Pickup measures only ½-in. in diameter and less than ¾-in in length. Its flush diaphragm is designed for insertion directly into a process vessel or stream of either liquid or gas for test and monitoring purposes.

Circle letter (AB) on reply card.

(AC) LEAKAGE TESTER

A new combined ohmmeter and leakage tester has been announced by Southwestern Industrial Electronics Company Model C-3 resistance meter is a compact, portable instrument designed for production testing of transformers, condensers, etc., with a useful range of 1 ohm to 1 million megohms. The four ohmmeter ranges are powered by a 1½ v battery. The six megohms ranges apply a maximum of 105 v to the unit under test, providing a quick and accurate indication of insulation resistance or dielectric leakage. The accuracy is plus or minus 3 per cent of full-scale deflection for all range except the highest megohms range which is plus or minus 5 per cent. The front panel is anodized and is equipped with a large rectangular meter.

Circle letter (AC) on reply card.

Trade Literature

Publication will be sent free.

(AD) VOLATILE LIQUID STORAGE

Chicago Bridge and Iron Company has recently issued an 8-page booklet, "The Hortonsphere." This booklet describes the advantages of storing highly volatile liquids and gases in Hortonspheres under pressure. Tables of sizes are included in the booklet. Hortonspheres for the storage of liquids range in capacity from 1000 to 30,000-bbl for operating pressures of about 30 to 215 psi. Hortonspheres for gas storage have been designed in standard sizes from 32 to 80 ft in diameter for operating pressures of 30 to 150 psi.

Circle letter (AD) on reply card.

(AE) INSULATED PIPE

Durant Insulated Pipe Company, Palo Alto, California, has a new bulletin (6c) on D. I. P. pre-sealed insulated pipe for underground and weather-exposed piping systems conveying hot or cold liquids or gases. Steam pressures up to 1000 psi. Bulletin gives applications, special features, design, construction, fabrication, and specifications. It is complete with many drawings, photos, and diagrams.

Circle letter (AE) on reply card.

(AF) WIRE ROPE

A new pocket size wire rope handbook is offered by A. Leschen and Sons Rope Company. This 64-page "Wire Rope Handbook" is claimed to help users become more expert wire rope buyers. It contains valuable, every-day information in handy size booklet that fits conveniently in a jacket pocket, or neatly on a shelf or in a desk drawer. The contents include descriptions, diagrams, and illustrations of wire rope types and constructions, as well as helpful information about lubricants, working loads, safety factors, and specifications.

Circle letter (AF) on reply card.

(AG) TRUCK CRANE

A new four color catalog describing the Model 75A and 75B shovels and the 75BT truck crane has been announced by Gar Wood Industries, Inc. This new catalog describes in detail the many construction and operational features such as the fluid coupling which absorbs and cushions shocks thereby prolonging the life of the unit. Other features described are the exclusive right angle gear drive which eliminates adjustments, and is completely sealed in oil. The new catalog also points out the ability of the 75's to hoist, swing, and travel simultaneously.

Circle letter (AG) on reply card.

(AH) RECORDER DATA

Bulletin 447, just issued by The Foxboro Company, contains complete details of temperature recorder construction, showing how each component part, from bulb to chart, contributes to recorder accuracy. Its 20 pages provide factual information, assisting in the understanding, selection and use of temperature measuring instruments.

Circle letter (AH) on reply card.

(AI) GENERATOR SETS

Diesel electric generator sets can be tailored to meet almost any power need, according to examples given by Caterpillar in its new booklet, "Generating Power and Profits." Whether the need is for direct or alternating current—and in the latter case, whether for single or three phase, 50 or 60 cycle—there is a combination available to meet requirements, it is stated.

Circle letter (AI) on reply card.

(AJ) WEIGHTING MATERIAL

A thorough and illustrative bulletin has been published by Baroid Sales Division, National Lead Company. Baroid is a weighting material manufactured from barytes (barium sulfate ore) prepared and packed especially for use in drilling oil and/or gas wells. Baroid is added to drilling muds to increase the unit weight of the mud, thus increasing the hydrostatic head on the formations being drilled, and confining oil, gas, and water to their respective horizons.

Circle letter (AJ) on reply card.

(AK) FLANGE, COUPLING

A revised edition of the popular flange and coupling selector, designed by the Nooter Corporation, is now available. In the same easy-to-read slide rule form, it provides all the information contained in the earlier selector (of which over 30,000 copies have been distributed), plus *new* and useful data. The flange size selector lists such relevant facts as the OD or flange, thickness, OD of Raised Face, etc. The Coupling Selector shows average sizes of standard, extra heavy, 3000 lb, and 6000 lb couplings.

Circle letter (AK) on reply card.

(AL) LUBRICATING OIL

"Spectrographic Analysis of Diesel Engine Lubricating Oil," published by American Locomotive Company of Schenectady, New York, tells in 78 pages of text and photographs how the spectrograph—a scientific instrument that can detect exceedingly small amounts of chemical elements in any substance—is now being used by diesel locomotive engineers to control engine maintenance and prevent costly breakdowns.

Circle letter (AL) on reply card.

(AM) PERFORMANCE EVALUATION

A comprehensive booklet "The Engine Indicator" has been prepared by The Cooper-Bessemer Corporation to assist operators of gas and diesel engines in keeping equipment at top operating efficiency by the use of the engine indicator. Prepared by J. D. Hines, research engineer, the booklet reviews the various types of engine indicators and points out limitations. Emphasis is made on the proper indicator and its correct application in improving performance of reciprocating engines and compressors.

Circle letter (AM) on reply card.

(AN) ROLLER CHAIN

The improved Baldwin assembly riveted roller chain is described in detail in a new bulletin, No. 52-3, now being distributed by Baldwin-Duckworth, Division of Chain Belt Company. One of the highlights of the book is the graphic section on how the chain is made up, not cut up, to any length. Features of the chain and the exclusive Baldwin-Rex single pin coupler link are illustrated and described. Assembly diagrams and charts are presented.

Circle letter (AN) on reply card.

(AO) CENTRIFUGAL PUMP

Allis-Chalmers broad line of centrifugal pumps applicable to most industries is highlighted in a new "Handy Guide to Selection of Centrifugal Pumps" released by the company. In addition to covering general purpose, double suction, multi-stage, special purpose, marine, and mixed and axial flow pumps, the bulletin has a head-capacity table for single stage, double suction Allis-Chalmers pumps. Special purpose pumps mentioned include solids handling, paper stock, sewage, rubber-lined, process, fractional horsepower and coolant and circulating units.

Circle letter (AO) on reply card.

(AP) GATE VALVE

Publication of a new six-page catalog section describing a new line of cast steel gate valves was announced by Edward Valves, Inc. The new booklet contains complete information on details of design, material specifications, etc. Features of gate valves described include close fitting guide ribs that prevent drag on seat faces, one-piece bonnets for accurate stem alignment, and ball bearing yokes for easy operation.

Circle letter (AP) on reply card.

(AQ) TOOLS

New 68-page catalog No. 301 is now available from J. H. Williams and Company. This catalog contains the entire line of Williams tools with illustrations, descriptions, and complete information about each item. Products featured include carbon and alloy wrenches of all types, detachable sockets and accessories, impact sockets, tool holders, "C" clamps, lathe dogs, chain pipe tongs and vises, and numerous other items.

Circle letter (AQ) on reply card.

Trade Literature

(AR) HARDFACING PROCESS

A new automatic hardfacing process using the standard automatic Heliweld head and a unit for feeding bulk tungsten carbide, has been announced by Air Reduction Company. Airco has developed an Automatic Heliweld hardfacing unit, which in operation, melts the base metal, producing an elongated pool and the tungsten carbide particles are poured into this pool behind the arc. The rate of tungsten carbide feed from the vibratory hopper is electrically controlled.

Circle letter (AR) on reply card.

(AS) FRAME TYPE PUMPS

Allis-Chalmers frame type centrifugal pumps designed to handle most ordinary pumping jobs requiring capacities up to 500 gpm and heads as high as 135 ft are described in a new bulletin released by the company. Built for V-belt drive, the frame type pump can be mounted in a variety of positions and connected to any type of prime mover without difficult alignment problems. Head and capacity can be changed by simply altering sheave size on the V-belt drive.

Circle letter (AS) on reply card.

(AT) PRODUCTS SERVICE

Lane-Wells Company, oil field service organization, has just issued a revised catalog covering its complete line of technical products and services for the oil industry. This latest issue, which commemorates Lane-Wells' 20th Anniversary of oil industry service, summarizes the latest information on perforating, radioactivity well logging, packers, and bridging plugs. The perforating section gives complete engineering specifications for the 21 types and sizes of perforators used in the company's bullet and Koneshot services.

Circle letter (AT) on reply card.

(AU) FLEXIBLE TUBING

A complete line of flexible tubing, in diameters from less than 1 to 30 in., is described in a new 4-page bulletin available from Flexible Tubing Corporation. The ducting, made of fabric supported rubber or plastic wound on helical spring wire coils, is lightweight, highly retractable, non-collapsable, non-kinkable, flexible enough to allow up to 180 deg turns, and requires no installation skill.

Circle letter (AU) on reply card.

(AV) POWER DIGGER

Sherman Products, Inc., has published a new folder showing the hydraulic Power Digger at work. The Sherman Power Digger is completely hydraulic, which gives the owner positive control. Piston rods are chrome plated to resist corrosion. Sherman Power Diggers are portable and is most useful for jobs where big equipment is impractical because of close quarters, size of the job, and transportation costs.

Circle letter (AV) on reply card.

(AW) INDUSTRIAL CHEMICALS

Tennessee Eastman Company, Division of Eastman Kodak Company, announces the publication of its 1953 catalog of Eastman Industrial Chemicals. An important addition to this year's catalog is the inclusion of those chemicals produced in whole or in part by Texas Eastman Company, Eastman Kodak Company's new chemical manufacturing division in Longview, Texas. Among those products resulting from the activities of the Texas division are n-butyric anhydride, isobutyraldehyde, isobutyl alcohol, isobutyl acetate, 3-methoxybutyl alcohol, 3-methoxybutyl acetate and di-isobutyl phthalate.

Circle letter (AW) on reply card.

(AX) CREOSOTE

Koppers Company, Inc., has announced the availability of a 12-page bulletin describing in detail advantages of creosote. Tests of the 162 compounds in creosote have shown that all are toxic to fungi and termites, the bulletin reports. The booklet is well illustrated with pictures of applications of creosote with a short discussion of its preservative powers.

Circle letter (AX) on reply card.

(AY) GAS HEAT

Radiant gas heat for processing liquids is the subject of a new bulletin by Selas Corporation of America, which describes fully the characteristics of combustion equipment and its applications to a wide variety of liquids requiring heat processing. Two types of burner settings, enclosed and open, are described. Typical installations are also shown. "Heat Processing Batch Liquids with Duradiant Clusters" is the title of the 12-page bulletin.

Circle letter (AY) on reply card.

(AZ) AUTOMATIC RELAYS

A complete line of telephone-type relays, including hermetically sealed (in metal and glass containers) sub-miniature, plug-in types, etc., is described in a new, color-illustrated brochure released by Automatic Electric Company.

The bulletin includes charts for ordering automatic electric relays, as well as a breakdown of all automatic electric relays.

Circle letter (AZ) on reply card.

(BA) POSITIONING OPERATOR

A pneumatic positioning operator designed for high speed positioning and regulating of heavy equipment is fully described in a bulletin recently published by Republic Flow Meters Company. Operation of the valve and actuating mechanism, helps enable the operator to overcome starting friction. A pneumatic electric flow meter for measuring widely fluctuating flows, dirty fluids, and other difficult fluids is described in a second bulletin recently issued by Republic Flow Meters. The flow meter can be adapted to operate at static pressures as high as 2000 psi and differential pressures 0.6 to 704 in.

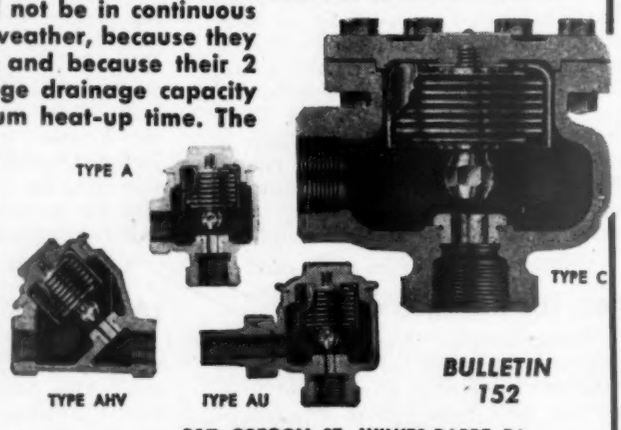
Circle letter (BA) on reply card.

NICHOLSON MAKES

Freeze-Proof Steam Traps

for Every Plant Use

Because they drain completely when cold, these four types of Nicholson steam traps are positively freeze-proof. Can be freely installed outdoors. Universally recommended for use in lines which need not be in continuous use during cold weather, because they are freeze-proof and because their 2 to 6 times average drainage capacity results in minimum heat-up time. The non-air-binding feature of Nicholson traps also notably facilitates heat transfer in severe weather. Sizes ¼" to 2"; pressures to 250 lbs.



BULLETIN 152

217 OREGON ST., WILKES-BARRE, PA.

W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

(BB) PNEUMATIC CONTROLLER

A new catalog from Fischer and Porter Company is now ready for distribution describing a completely new P-4 Pneumatrol pneumatic controller for rate of flow, differential pressure, liquid level, viscosity, pressure, and temperature applications. This controller is usable for either single or dual instrument case mounting and for point-of-measurement installation as well.

Circle letter (BB) on reply card.

(BC) EMULSION TREATERS

The Parkersburg Rig and Reel Company has published a 48-page bulletin on emulsion treaters. It covers both the company's line of vertical type treaters as well as the horizontal type many operators prefer. The bulletin contains numerous charts, drawings, cutaway diagrams, and pictures, all serving to present the various factors to be considered when selecting a treater.

Circle letter (BC) on reply card.

(BD) WELDING ALLOYS

Just published is a wall-chart 18 by 27 in., designed to aid welders, on the job, to select the particular All-State alloy and flux that will best serve the welding, brazing, soldering, cutting, or tinning job at hand and at the least cost. Data on 41 alloys and appropriate fluxes are arranged so as to make accurate selection as nearly automatic as possible.

Circle letter (BD) on reply card.

(BE) PUMPS

Marlow Pumps has just released a newly-revised four-page two-color version of its Bulletin G-52 covering their complete line. Designed as a review and reference bulletin, the new brochure contains pictures of representative units and general descriptive matter covering each type of Marlow pump.

Circle letter (BE) on reply card.

(BF) GUM INHIBITOR

The use of gum inhibitors to effectively delay gasoline deterioration during storage is discussed in a new bulletin published by Tennessee Eastman Company. The bulletin contains information on the causes of gum formation, the use and handling of inhibitors, and discusses those factors that must be considered when a selection of an inhibitor is made for a specific gasoline.

Circle letter (BF) on reply card.

(BG) ELECTRODES

Alloy Rods Company has published a new 4-page bulletin on its New "Nickel-Arc 60" electrodes for machinable welds on cast iron. The new electrodes are designed for fast welding of all types of cast iron. They have an easy-to-control arc, with spatter-free action on a-c or straight polarity d-c. Coating is claimed to be free from injurious gases, and electrodes are said to be ideal for repairing broken or worn castings and casting defects, or correcting machining errors.

Circle letter (BG) on reply card.

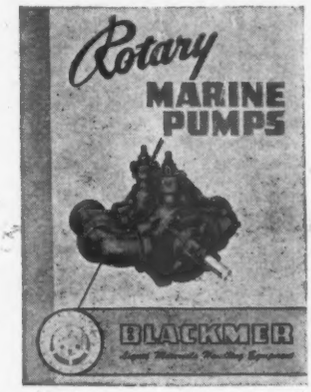
(BH) STUCK PIPE RECOVERY

A new 4-page, illustrated, technical folder, No. 401, on back-off service has just been released by the McCullough Tool Company. This folder gives a complete description of the applications and operation of the McCullough Magna-Tector and String Shot. It gives full details on the use of these two tools in recovering stuck pipe and describes unusual jobs that have been accomplished.

Circle letter (BH) on reply card.

(BI) CARGO PUMPS

A new Blackmer marine pump bulletin illustrates 300 to 1500 gpm cargo



handling pumps for dock and deck mounting to transfer alcohols, oils, liquid fuels, solvents, etc. Also shown in the 4-page, 2-color bulletin are 10 to 300 gpm pumps for engine room fuel and lube service.

Circle letter (BI) on reply card.

(BJ) CHEMICAL PUMPS

Byron Jackson Company has published a four-page bulletin on centrifugal pumps and their wide range of pumping applications. Two complete cutaway diagrams of the new BJ chemical pumps are included, showing the interchangeability of parts. The new chemical pumps are quick and easy to dismantle for inspection and repair without disturbing piping or driver. All parts interchangeable except pump case and impeller.

Circle letter (BJ) on reply card.

(BK) ENGINE ATTACHMENTS

"Attachments for Your Caterpillar Diesel Engine" is a 32-page booklet published especially for anyone considering an engine installation. It contains the most complete selection of attachments ever presented by Caterpillar in booklet form. The attachments are pictured and described clearly.

Circle letter (BK) on reply card.

(BL) FLOW METERS

Minneapolis-Honeywell Regulator Company has a new bulletin, Catalog 2300, which presents the new line of Honeywell evenly graduated flow meters for measurement, recording, indication, and integration of fluid flows. The characterized bell for square root extraction and the electronic integrating mechanism are covered in detail.

Circle letter (BL) on reply card.

(BM) VERTICLOSED MOTORS

Users of deep well turbine pumps will find many interesting developments in vertical motor design in a new 16-page bulletin just off the press featuring U. S. Electrical Motors, Inc., Verticlosed motors. Numerous design improvements are presented. The bulletin illustrates the motor with accompanying drawings of individual features in full color.

Circle letter (BM) on reply card.

(BN) DATA SHEETS

Davison Chemical Corporation has published new data sheets on its new line of products, the organic silicofluorides. As has been reported already, the company has succeeded in producing these chemicals commercially—they were formerly only known as laboratory curiosities. The loose leaf sheets contain formulas listing typical properties and possible uses.

Circle letter (BN) on reply card.

(BO) WELD PIPE

Kaiser Steel Corporation has published a new bulletin titled "ERW Electric Resistance Weld Pipe." The bulletin states that the new Kaiser ERW pipe is made of open hearth steel, and is easy to weld. Its roundness and concentricity make for speedy line-up, and the electric resistance welding process employs no extraneous metal. The booklet contains pictures and diagrams that show step by step how Kaiser ERW is made.

Circle letter (BO) on reply card.

(BP) SODA BLEACH SOLUTION

"Diamond Soda Bleach Solutions"—a technical guidebook holding special interest for industrial users of sodium hyphochlorite solutions—has just been issued by Diamond Alkali Company. Included are data reviewing the latest approved and standardized procedures in daily plant practice to prepare sodium hypochlorite solutions.

Circle letter (BP) on reply card.

(BQ) 60th ANNIVERSARY

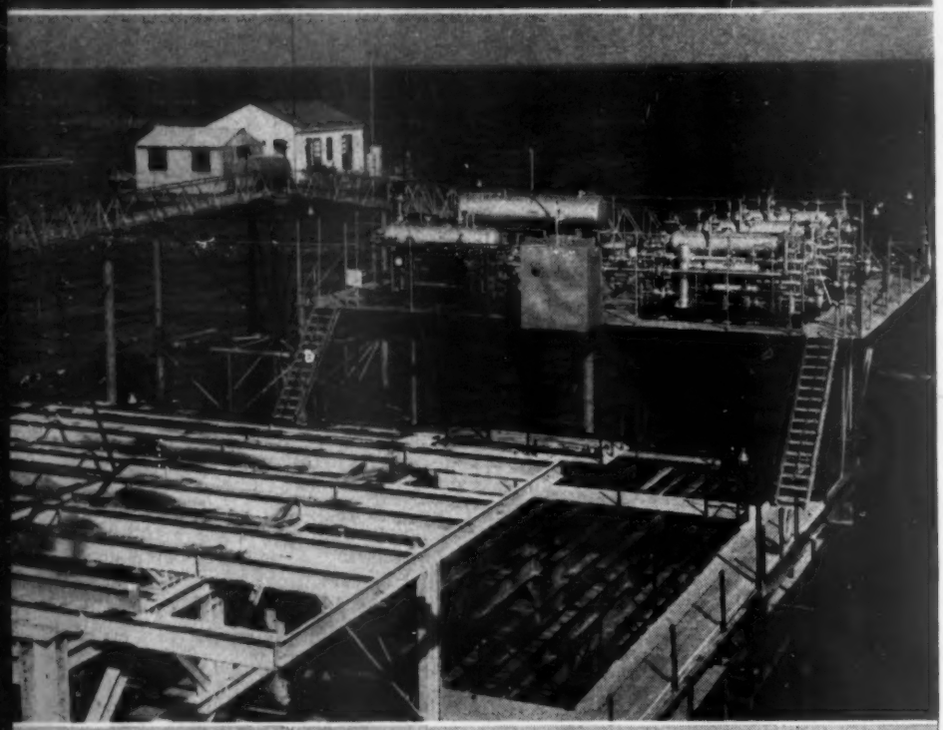
The Gustav Wiedeke Company has announced its 60th anniversary in a leaflet depicting its tools. The leaflet shows the company's various type of tube expanders, self-feeding hand tube cutter, and a list of distributors through the United States. It gives the various catalog and bulletin numbers for more detailed information of its products.

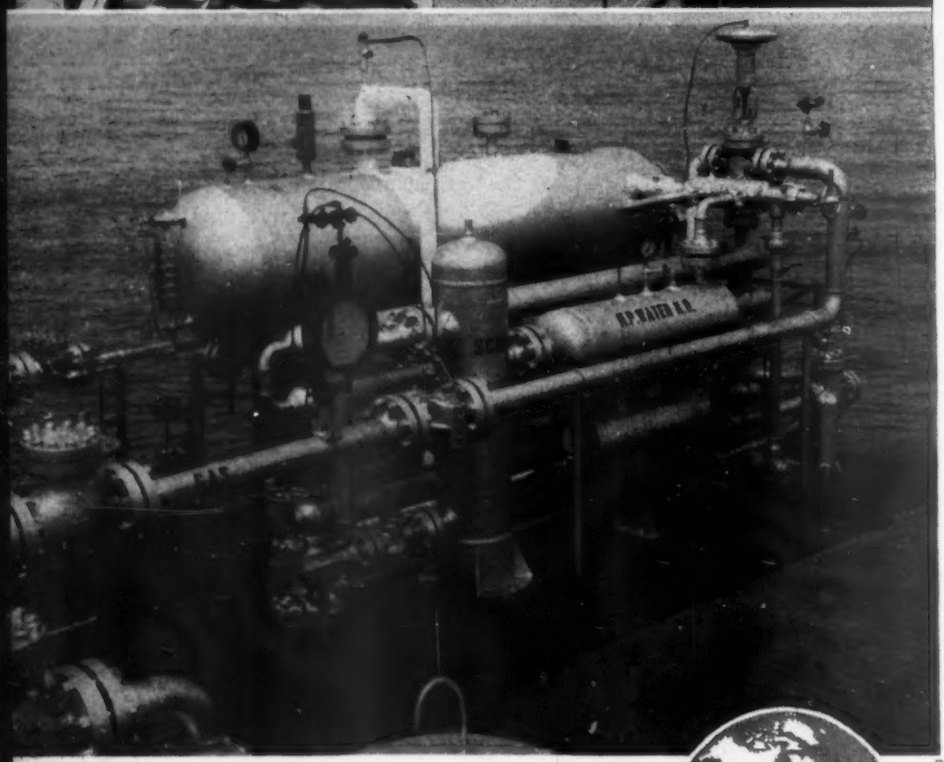
Circle letter (BQ) on reply card.

(BR) ORIFICE FITTINGS

Robinson Orifice Fitting Company has announced the availability of its new catalog covering the entire line of orifice fittings and accessory equipment. The two-color booklet contains many drawings, pictures, and charts, and a description of its orifice fitting designs. The company terms the Robinson Type E one of the most outstanding. It is possible to change orifice plates of the Type E fitting without interrupting the flow through the pipe line and without use of a bypass.

Circle letter (BR) on reply card.





OCEAN GOING LTX*

Eight miles off the coast of Vermillion Parish, Louisiana, in 40 feet of Gulf water, stands the first "ocean going" gas gathering line. Four directionally drilled gas-condensate wells are produced. Liquid is separated AT THE WELL.

The following standards for the separation equipment were set by the producing company:

1. Take shutin pressure of 3000 p.s.i. and step down to 1200 p.s.i. for pipe line.
2. Processed gas could contain no more than 14 lbs. water per MM cu. ft. with 7 lbs. preferred.
3. Separate maximum amount of distillate and free water.
4. Individual units for each well with minimum capacity of 10 MM cu. ft./day.
5. Added safety equipment to automatically shut in wells in event of disturbance.
6. Units had to be compact and complete with a mud and sand trap along with gas and distillate meter runs.

National equipment exceeded these specifications. NATIONAL LTX UNITS WERE CHOSEN.

First gas began to flow in early 1951 WITH A REMARKABLY LOW WATER CONTENT OF 4 LBS. PER MM CU. FT. OF GAS.

May we help you in solving your distillate extraction problems? Write for a paper covering full description of this installation.

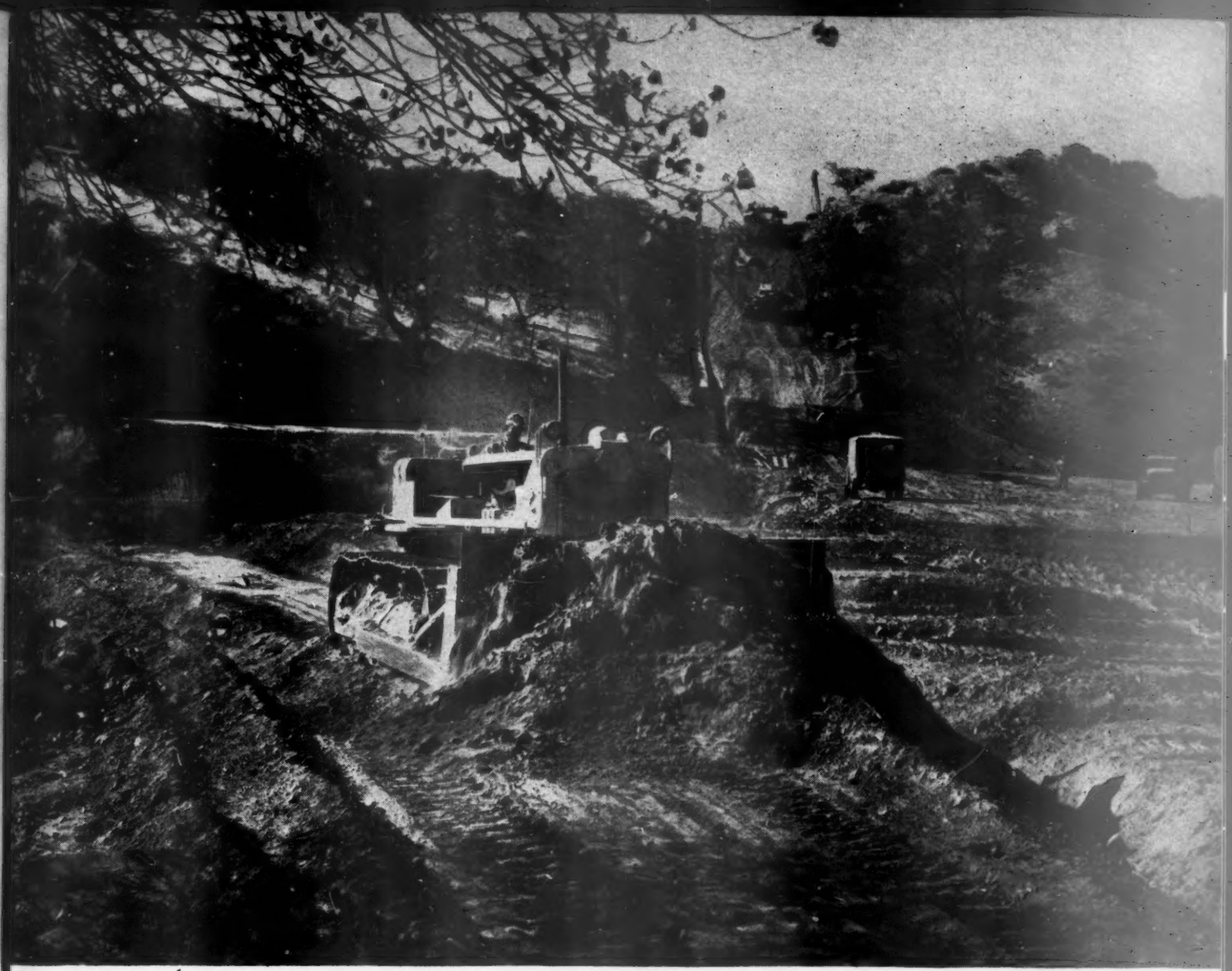
*TM Reg. U.S. Pat. Off.

It's a National

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

11-9-52



PUTTING THE SUPER INCH TO BED

From Needles on the Arizona border to Milpitas in Santa Clara County, California's 501-mile Super Inch has recently joined a 1,600-mile system bringing natural gas from Texas and New Mexico. The stretch you see here is near Llanada, Calif., where Bechtel-Price-Conyes of San Francisco used a "Caterpillar" Diesel D8 Tractor with No. 8S Bulldozer for backfilling. This big yellow team tucks in the 34″ pipe neatly and quickly, helping to wrap up a 63 million dollar job.

The Super Inch cut its way through all kinds of country, some of it steep, some of it sandy, all of it rough. The "Cat" 8S 'Dozer is right at home on jobs like this. Its side arms are of rugged box-section construction. Its scientifically curved blade rolls the load ahead smoothly, while its high carbon steel cutting edge combines just the right degrees of hardness and toughness. Its cable controls give accurate, smooth operation under the severest conditions. And it adjusts easily for tilt and pitch.

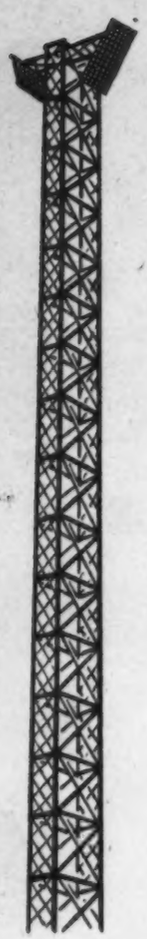
There's a "Caterpillar" Bulldozer for any job, built to match its running mate, the brawny Diesel Tractor. And there's a "Caterpillar" Dealer nearby with all the information you want. See him now.

CATERPILLAR TRACTOR CO., PEORIA, ILLINOIS

CATERPILLAR

REG. U. S. PAT. OFF.

DIESEL ENGINES
TRACTORS • MOTOR GRADERS
EARTHMOVING EQUIPMENT



Dependable Communications —by the Bell System

In recent months the tens of thousands of miles of Bell System intercity private line services for pipe line, power and railroad companies were on the job 99.79 per cent of the time.

This high degree of reliability is made possible by a large force of trained specialists in the field. These men are on the job 24 hours a day, 365 days a year. When there is an interruption in service, they move in rapidly to restore it.

In most cases, they can quickly set up alternate routings in emergencies because of the Bell System's nationwide network of wire, cable and microwave.

• • •

For good, dependable communications get in touch with your nearest Bell Telephone Company representative. He will be glad to study your communications problems and requirements without charge and recommend service that will meet all of your needs.

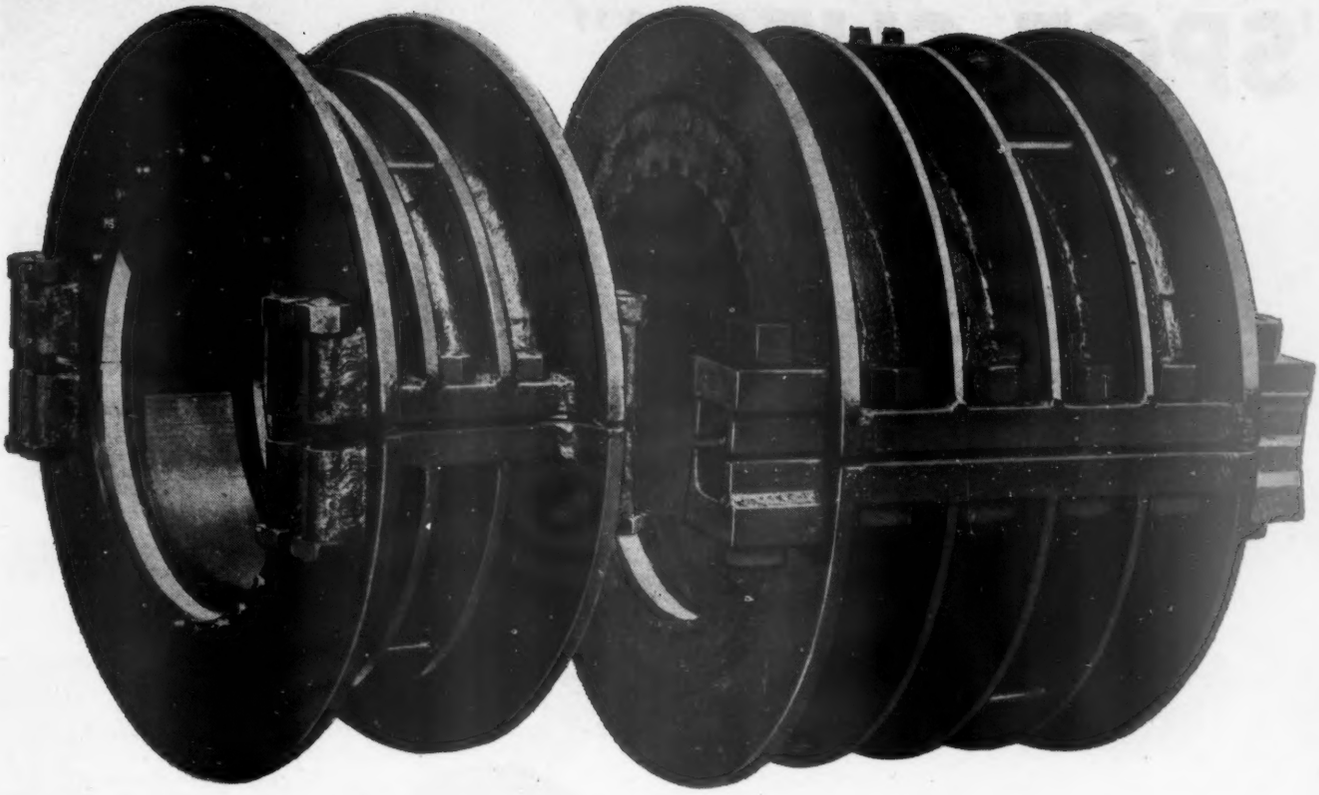
PRIVATE-LINE TELEPHONE

TELETYPEWRITER

MOBILE TELEPHONE

METERING CHANNELS

BELL TELEPHONE SYSTEM



NOW YOU CAN BANDAGE THE BIG ONES

These 26″ O.D. sleeves illustrate how sleeve lengths and strength may be increased as required. Both sleeves are for 1,500 psi pressures.

with high-pressure Dresser Repair Sleeves for lines up to 1,500 psi or greater

Now Dresser offers you split repair sleeves for lines operating at pressures up to 1,500 psi or even higher—sleeves of various lengths, for diameters up to 30″ or larger. These are in addition to the regular Style 93 and Style 96 Sleeves for ordinary pressures up to 500 psi.

You'll want to do as many companies do—stock several Dresser Repair Sleeves for each of their principal pipeline sizes. It's cheap insurance that pays off in emergencies.

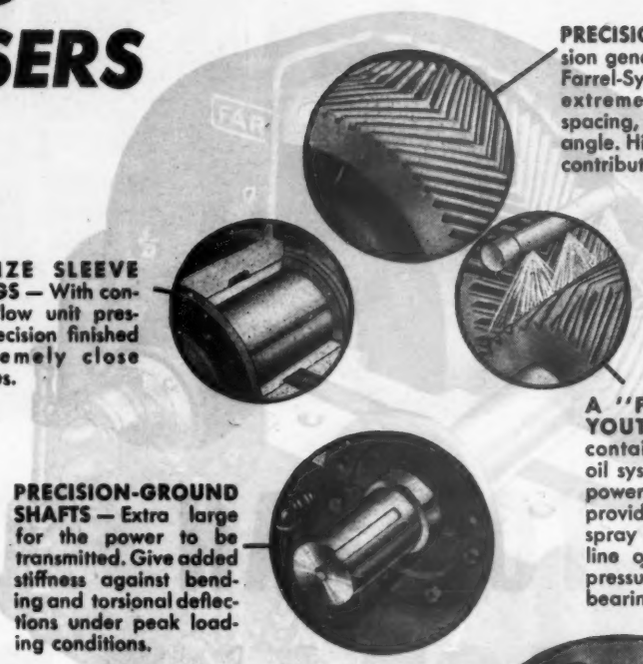
Style 93 Repair Sleeves completely enclose and repair plain, butt, bell-and-spigot and double-bell circumferential welded joints, screw collars—holes and splits in the run of pipe. Style 96 Sleeves have inside clearance enough to enclose mechanical or welded joints too large for the Style 93.

Both sleeves employ the pipeline-proved Dresser rubber-compound pack and are vented for installation under pressure. Sleeves are factory-assembled—no need for fussing with loose parts, cutting and fitting gaskets, caulking or welding. The repair is safe, sure, permanent. Available in full range of sizes 6″ through 30″ and larger. Send your order today.

DRESSER *Repair Sleeves*

Dresser Manufacturing Division, 59 Fisher Ave., Bradford, Pa. (One of the Dresser Industries) • In Texas: 1121 Rothwell St., Houston • In Canada: Dresser Mfg. Co., Ltd., 629 Adelaide St., W., Toronto, Ont. • Sales Offices: New York, Chicago, Houston, San Francisco

"SPOT CHECK"
of features of FARREL® SPEED INCREASERS



PRECISION GEARS — Precision generation by the famous Farrel-Sykes process results in extreme accuracy of tooth spacing, contour and helix angle. Highest grade materials contribute to long gear life.

OVERSIZE SLEEVE BEARINGS — With consequent low unit pressures. Precision finished to extremely close tolerances.

A "FOUNTAIN OF YOUTH" — The self-contained circulating oil system virtually puts power on "velvet" by providing a protective spray of oil at the mesh line of the gears and pressure lubricating the bearings.

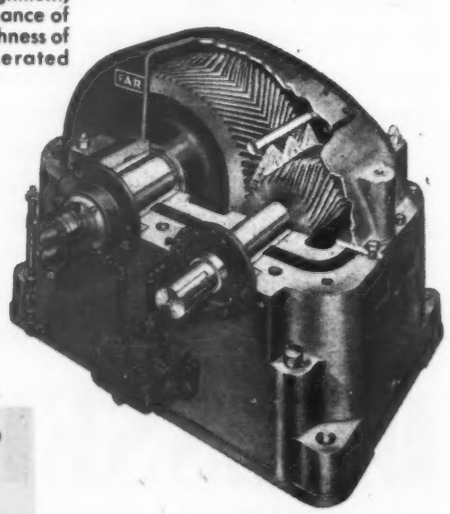
PRECISION-GROUND SHAFTS — Extra large for the power to be transmitted. Give added stiffness against bending and torsional deflections under peak loading conditions.

These are the features which account for the amazing record of Farrel speed increasers in pipeline pumping service.

Although hundreds and hundreds of these units have been installed in pumping stations, not one has ever failed on the job. In fact, every unit placed in service since 1932, when the line was first developed, is still operating successfully.

For further details of these proved-on-the-job speed increasers, send for a copy of bulletin 448A. No cost or obligation.

EXCEPTIONALLY RIGID HOUSING — Holds rotating elements in original alignment, insuring maintenance of operating smoothness of precision - generated gearing.



FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.

Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Detroit, Chicago, Memphis, Minneapolis, Portland (Oregon), Los Angeles, Salt Lake City, New Orleans

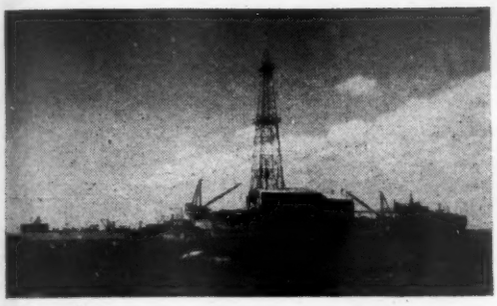
OIL FIELD REPRESENTATIVES:

Hercules-Lupfer Engine Sales Co., 124 N. Boston St., Tulsa 1, Okla.
V. W. Osborne, 860-A M&M Bldg., Houston 2, Texas

Farrel-Birmingham®

FB-773

How Shell Oil does its exploration, drilling, transporting and refining more efficiently with MOTOROLA 2-WAY RADIO



Motorola 2-way radio is the vital link in offshore drilling operation. Instant communication gets needed supplies, saves time in emergencies.

The widespread operations of Shell Oil Company depend upon Motorola 2-way radio for the fast, reliable communication that reaches key men in every area. Offshore drilling operations, exploration parties and docking facilities are linked together for the co-ordinated action that improves service and protects personnel.

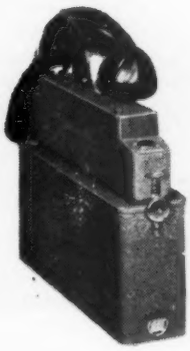
Throughout the Petroleum Industry, Motorola is specified for low overall investment, reduced maintenance cost and top-notch performance. Rough-and-ready Motorola radios take the hardest shocks and jolts, deliver peak performance under all conditions. They're built for the future, too, with obsolescence-proof circuits that guarantee dependable service for years to come.

Central Station Console—the Key Control Point

Conveniently located, easily operated console puts full transmitter power at your finger-tip. Microphone, speaker and clock are placed where you need them for fast dispatching and timed message-handling.

Handie-Talkie® Portable Radiophone

A complete 2-way radio ready for instant action wherever you go. Exploration parties find the *Handie-Talkie* radiophone indispensable. It's a *lightweight* in size, a *heavyweight* in performance.



Motorola

Communications & Electronics Division
4545 Augusta Blvd., Chicago 51, Illinois
Rogers Majestic Electronics Ltd., Toronto, Canada

Isn't it logical?

First, Hill, Hubbell cleans the pipe to bare bright metal by Roto-Grit Blast. Then, temperature of pipe and coating and wrapping materials is precisely controlled at every step of the process.

Isn't it logical that factory-coated pipe should last longer? As a final precaution, every length of pipe protected by Hill, Hubbell is inspected with electronic holiday detectors before leaving the factory.

Hill, Hubbell and Company

Division of GENERAL PAINT CORPORATION

Headquarters: 3091 Mayfield Road, Cleveland 18, Ohio

Leaders in Pipe Protection for a Quarter Century

PLANTS

Lorain, Ohio; Youngstown (at Girard, Ohio); Chicago Area—Hammond, Indiana (Gibson Yard) ★

★ Railroad in transit privileges

We hope he's on his way to your house..
GASO PUMP & BURNER MFG. CO.
902 EAST FIRST ST., TULSA, OKLA.
Good Health
Good Wealth
Good Cheer
Colicki

You can't get caught in this trap!

NO threads to gall or freeze
NO leaky seals
NO doubt about strength—
conforms to all codes
NO multi-bolt flanges
NO thing to drop

That's UNIBOLT

Self-Sealing Gasket—made of Hycar (oil and gas resistant rubber)—is the final answer to scraper trap leaks. Its lipped design makes it self-sealing under line pressure. The coupling cannot be overtightened to the extent of damaging the gasket or the coupling itself.

Release two bolts. Swing the trap open. Take the pig out or put the pig in. Close the trap and tighten two bolts. That's just how simple and easy it is to operate a UNIBOLT Scraper Trap. An oversize barrel (slightly larger than the o.d. of the pig) makes it equally easy to start a pig. Line pressure does the heavy work.

Pipeliners everywhere are using UNIBOLT closures and couplings for scraper traps, blowdowns, strainers, mist removers and other large diameter pressure vessels. A UNIBOLT representative will gladly explain the advantageous features of these products to you.

THORNHILL-CRAVER CO.

P. O. BOX 1184 UNIBOLT THE ONE BOLT COUPLING **HOUSTON, TEXAS**